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WATER SUPPLY AND WATER QUALITY CONTROL STUDY

STONEWALL JACKSON RESERVOIR, WEST FORK RIVER BASIN, WEST VIRGINIA

PUBLIC HEALTH SERVICE

FEBRUARY 1965

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WATER SUPPLY AND WATER QUALITY CONTROL STUDY STONEWALL JACKSON RESERVOIR WEST FORK RIVER BASIN WEST VIRGINIA

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Study of Needs and Value of Storage for Municipal and Industrial Water Supply and Water Quality Control

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region III
Charlottesville, Virginia

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region III
Ohio River Basin Project
Wheeling Field Station, West Virginia

In Cooperation With The

U. S. DEPARTMENT OF THE ARMY
U. S. Army Engineer District - Pittsburgh, Pennsylvania

February 1965

ABSTRACT

A survey has been made which discloses a future need for municipal and industrial water supplies and an immediate need for storage for streamflow regulation for the purpose of water quality control. These conclusions are based on results of economic and demographic studies. Future needs are based on projected population and industrial growth.

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I. INTRODUCTION

Request and Authority

This study was initiated at the request of the District Engineer, U. S. Army Engineer District, Pittsburgh, Pennsylvania, by letter dated April 26, 1963. The letter requested the cooperation of the Public Health Service in determining the present and future municipal and industrial water supply needs and the need for storage for the regulation of streamflow for water quality control and the value of benefits which could be provided by a reservoir on the West Fork River at Brownsville, West Virginia. The Corps of Engineers is reviewing its report titled "Report Upon West Fork River and Tributaries, W. Va., Multiple-Use Reservoirs, 15 February 1955," which was prepared in accordance with the Flood Control Act of 18 August 1941.

Authority to conduct this study is provided in the Federal Water Pollution Control Act (Public Law 84-660, as amended by Public Law 87-88) and in a Memorandum of Agreement, dated November 4, 1958, between the Department of the Army and the Department of Health, Education and Welfare, implementing the Water Supply Act of 1958 (Title III of Public Law 85-500, as amended by Public Law 87-88).

Purpose and Scope

The purpose of this study is to determine the need for and value of storage for municipal and industrial water supply and for the regulation of streamflow for water quality control in the study area. The study area covers the West Fork River Basin and the area along the Monongahela River to the Ohio River. Project needs and benefits have been evaluated on a 50-year basis.

Acknowledgments

Information and cooperation provided by the following agencies are gratefully recognized:

U. S. Army Engineer District, Pittsburgh, Pennsylvania

U. S. Geological Survey

West Virginia Department of Natural Resources,
Division of Water Resources.

West Virginia Department of Health

Pennsylvania State Health Department

Allegheny County Planning Commission

Clarksburg Water Board

Fairmont Water Department

Morgantown Water Commission

Charleroi Water Authority

South Pittsburgh Water Company

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The proposed multiple-purpose Stonewall Jackson Reservoir would be located on the main stem of the West Fork River near the town of Brownsville, which is about three miles south of Weston, West Virginia.
2. The West Fork River Basin covers 881 square miles in northern West Virginia. It is tributary to the Monongahela River, which flows through western Pennsylvania in a northerly direction to subsequently form the Ohio River at the confluence with the Allegheny River.
3. The average annual discharge of the West Fork River at Brownsville, based on 16 years of record (1946-1962), is 171 cubic feet per second. The maximum discharge was 6,420 cfs, occurring on June 25, 1950, while no flow occurred during 19 days in 1951 and during several days in other years.
4. The population of the West Fork River drainage area is approximately 166,000, about 90,000 of whom reside in communities. The economic study is based on the counties most nearly coincident with the drainage basin and therefore includes areas outside the basin. The economic study area has a population of 231,900. More than half the basin population is classed as urban and is centered mainly in the three communities of Fairmont, Clarksburg, and Weston.
5. The present municipal water use by the 15 principal communities in the West Fork River Basin is about 15 mgd. Surface supplies account for 14.12 mgd of this use.

6. The water quality of the upper reaches of the West Fork River is generally good. However, acid conditions prevail on most of the tributaries that drain coal mining areas and these, in turn, degrade the quality of the main stem, especially downstream from Clarksburg.

7. The area along the Monongahela River below the West Fork River is highly industrialized. The greatest use of the Monongahela River for municipal and industrial water supply and for waste disposal occurs in the vicinity of Pittsburgh. Water navigation and the close proximity to vast coal reserves have been major factors in this development.

8. The 1960 population of the Monongahela River economic study area was 2,675,531. This area includes the Pittsburgh Standard Metropolitan Statistical Area.

9. Municipal water use of the Monongahela River through-out its length is almost 83 million gallons per day and serves an estimated 600,000 persons (139 gpcd). Industrial water use in this reach is slightly in excess of 1720 mgd for process purposes plus an additional 4,360 mgd used for cooling purposes. The Monongahela River receives acid mine drainage, sewage, and industrial wastes.

Conclusions

1. The population of the West Fork River Basin economic study area is expected to increase from 232,000 as of 1960 to about 336,000 by 2010. The population of the Monongahela River economic study area is estimated to increase from 2,675,531 to 4,100,000 by 2010.
2. The West Fork River provides a source of municipal and industrial water for both Clarksburg and Weston, and by the year 2010, the demand is expected to approach 51 mgd.
3. Based on projections of industrial employment and associated populations, municipal and industrial water use in the Monongahela River is expected to increase to about 2,997 mgd (excluding cooling water use) by year 2010.
4. Since the Monongahela River is entirely canalized, water is available to meet present and future municipal and industrial water supply needs, except as reuse of the stream may be limited by excessive quality degradation. No storage for municipal and industrial purposes along the Monongahela River is needed in the proposed project to meet anticipated needs over the next 50 years.
5. The reach of the Monongahela River in the vicinity of Pittsburgh is expected to continue to receive the greatest waste load of the entire stream system. Even with provision of adequate treatment of municipal wastes and treatment of equivalent control of industrial wastes, summer flows of as high as 4,000 cfs will be needed to assimilate anticipated organic waste loads by 2010. This exceeds the present dependable flow of the

Monongahela River at Pittsburgh. If streamflow were maintained to meet quality control needs in the Pittsburgh area, sufficient flows would be available for quality control purposes in upstream reaches between Pittsburgh and the Stonewall Jackson Reservoir; however, as the proposed reservoir could provide only a small portion (4 to 17%) of this requirement, eventual development of other proposed projects would be needed to provide the desired minimum future streamflow.

6. Regulation of streamflow by the Stonewall Jackson Reservoir could provide increased assured flows in the West Fork, Monongahela and Ohio Rivers, improve dissolved oxygen concentrations, reduce hardness and acidity concentrations, and result in other water quality improvements.

7. The benefits estimated in this study are predicated on the release of a relatively uniform quality of water from Stonewall Jackson Reservoir. If the quality of the discharge is reduced as a result of thermal stratification, density underflow, or other conditions, then benefits will be reduced. Multiple-level outlets, together with information on water quality at several depths would make possible the flexibility in management necessary to maintain acceptable dissolved oxygen, uniform temperatures, and minimum acidity concentrations in reservoir discharges. Provision should therefore be made in the design of Stonewall Jackson Dam for multiple-level outlets and access for water quality monitoring equipment.

8. Storage to yield 2.8 mgd is needed by the City of Weston to meet present and future municipal water needs. Provision of storage in the Stonewall Jackson Reservoir to provide these needs would result in benefits having an estimated average annual value of $13,[illegible]00.

9. Storage to yield 11.1 mgd would be needed by the City of Clarksburg to meet expected municipal water needs after the year 1980. Provision of storage in the Stonewall Jackson Reservoir to provide these needs would result in benefits having an estimated average annual value of $46,600.

10. About 471,500 acre-feet of additional annual draft-on-storage would be needed by 2010 to assure the estimated quality control flow schedule that is expected to be needed in the Monongahela River near Pittsburgh, Pennsylvania. Approximately 12,200 acre-feet of annual draft-on-storage would be needed above Clarksburg, West Virginia on the West Fork, Monongahela River. Provisions of storage in the proposed Stonewall Jackson Reservoir to meet the water pollution control needs in the West Fork, Monongahela River would also satisfy a portion of the pollution control needs (471,500 acre-feet in the year 2010) on the Monongahela River downstream from the confluence of the West Fork, Monongahela River. A range of storage volumes in acre-feet and related value of benefits for the provision of these quantities is shown as follows:

Annual Draft-on-Storage *	Average Annual Benefits (dollars)
20,000	350,000
40,000	700,000
60,000	1,050,000
80,000	1,400,000

These benefits are based upon adequate treatment** of organic wastes discharged to the stream and adequate control of acid pollution.

11. While the benefits discussed apply primarily to the West Fork and Monongahela Rivers, widespread benefits to water quality would also be realized along the entire length of the Ohio River. Such benefits are not possible to evaluate at this time.

12. These storage needs and benefits are subject to review and revision based on comprehensive studies of the Ohio River Basin currently under way, but they may be used for project evaluation at this time.

* Annual draft-on-storage is the sum of incremental excesses of needed releases over inflows during a climatic year.

** See page 55, first line, for definition.

III. PROJECT DESCRIPTION

Location

As presently proposed, the Stonewall Jackson Reservoir would be located on the West Fork River in proximity of the town of Brownsville, which is located about three miles south of Weston, West Virginia. (see Figure I and Figure III at back of report). Brownsville is located about 72 miles upstream from the mouth of the West Fork River. The project, as planned, would provide storage for flood control, water supply, water quality and recreation.

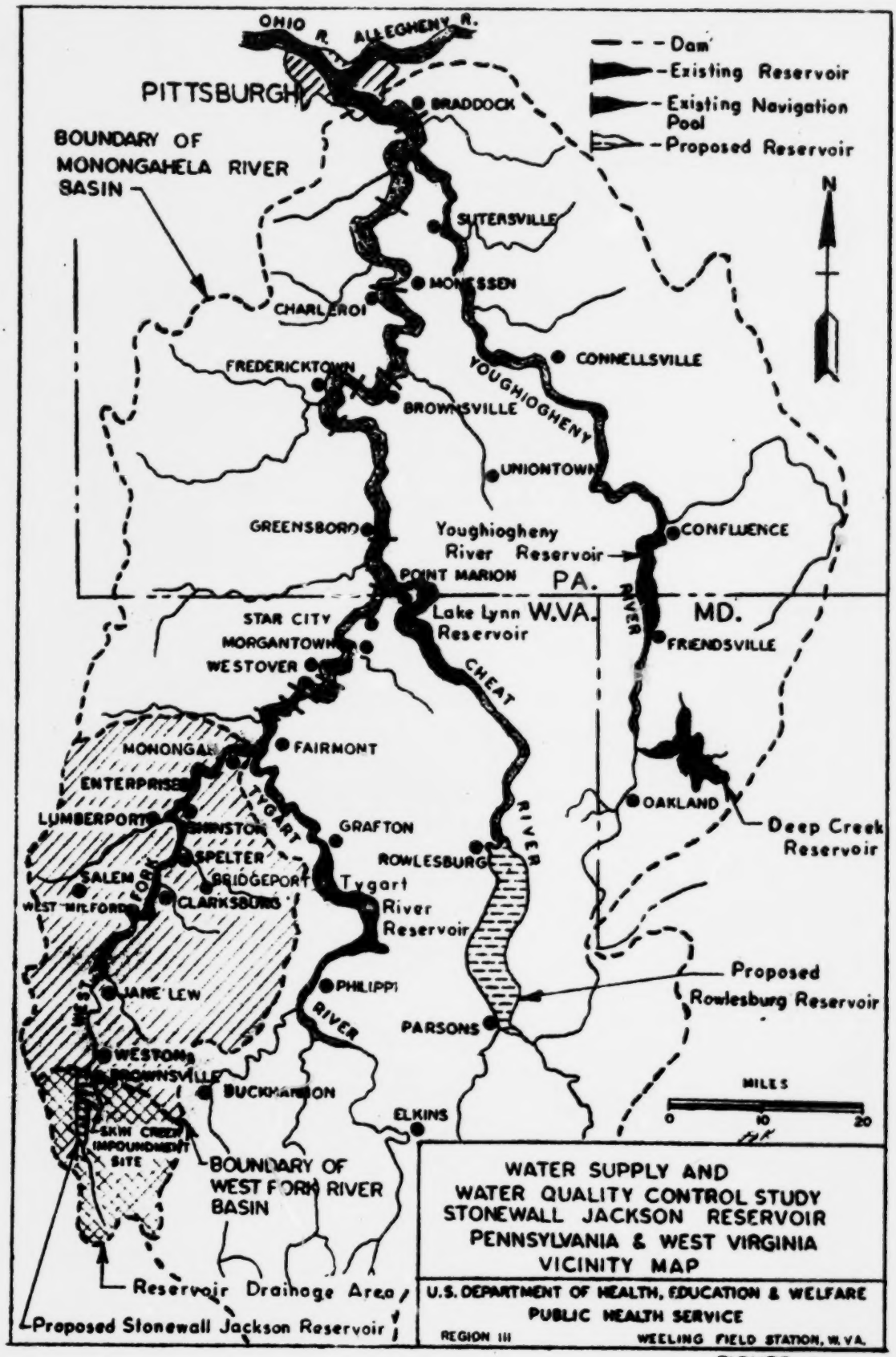
Streamflow

The average discharge of the West Fork River at the Brownsville USGS gaging station for 16 years (1946-1962) was 171 cfs from 102 square miles of drainage area. At this station a maximum recorded discharge of 6,420 cfs occurred on June 25, 1950; a minimum of zero flow occurred on several days during 1951 to 1954. The minimum average 7-day streamflow at Brownsville with a return frequency of once-in-ten-years is zero flow.

Water Quality

Water quality of the West Fork River at the reservoir site is generally good. Records of water analysis provided by the Corps of Engineers, show that the pH of the West Fork River at Brownsville has dropped from an annual median of 6.5 in 1954 to a present median of 6.2 in 1963.

It is anticipated that water stored in the proposed reservoir during periods of high flows will be of lower acidity than natural low flows. Hence, reservoir releases are expected to have acidity lower than that



WATER SUPPLY AND
WATER QUALITY CONTROL STUDY
STONEWALL JACKSON RESERVOIR
PENNSYLVANIA & WEST VIRGINIA
VICINITY MAP

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION III — WEELING FIELD STATION, W. VA.

FIGURE 1

of uncontrolled low flows.

Estimates of improvement in water quality are presented later in the report. These estimates are based on simulated changes with the reservoir in operation, assuming natural flow and water quality conditions equivalent to those of the past nine years. Twice-monthly records of water quality were used.

Data from the water quality station at Brownsville (1954 to 1963) show the following ranges of water quality:

pH	6.0 - 7.0
Free CO_2	6-27 mg/l
Mineral Acidity	0
Total Acid	6-27 mg/l
CO_3	0
HCO_3	7-45 mg/l
Total Alkalinity	7-45 mg/l
Hardness	17.1 - 51.3 mg/l

Pertinent Data

Some physical data on the proposed reservoir are presented below:

	Elevation ft.	Surface Area Acres	Storage Acre-feet
Flood Control	1,082	3,290	
Summer Pool			27,200
Winter Pool			38,200
Proposed Water Quality and/or Water Supply			
Summer Pool	1,073	2,530	46,200
Winter Pool	1,067.5	2,100	35,200
Minimum Pool	1,034	200	2,000
Streambed	1,007		
Total Storage			75,200

IV. STUDY AREA DESCRIPTION

Location and Boundaries

The study area includes all of the West Fork drainage area and the Mainstem Monongahela River downstream to Pittsburgh.

The West Fork River basin contains all of Harrison County with Clarksburg, the largest city in the basin; the major part of Lewis County with Weston, its largest city; and a part of Marion County with its largest city, Fairmont. Parts of Barbour, Taylor, and Upshur Counties within the basin contain no large centers of population or industry. Refer to Figure I and Figure III (in back of report).

The Monongahela River passes through an area of heavy industrialization, the concentration of which progressively increases toward Pittsburgh. These industries are involved chiefly in the manufacture of iron and steel. The Monongahela River is extensively used for navigation and is canalized to and above the mouth of the West Fork River for that purpose.

Geography and Topography

The West Fork River basin has a total drainage area of 881 square miles which extends in a north-south direction about 48 miles with an average width of about 18 miles. General drainage of the basin is in a northerly direction. The valleys of the river and its tributaries afford the only flat land in the basin. The West Fork River joins the Tygart River at Fairmont, West Virginia, to form the head of the Monongahela River.

There is a difference of approximately 1,110 feet in elevation between

the lowest point in the West Fork River Basin,at Fairmont, and the highest ridge in the eastern part of the basin. The river is in a mature stage of physiographic development, all its channels having been reduced essentially to grade. Its average gradient within Harrison County is 2 feet per mile. The principal tributaries are in a less advanced stage of development.

The Monongahela River basin is located in the southwest corner of Pennsylvania, the northeast portion of West Virginia, and includes a small section of western Maryland. The river flows in a northerly direction about 129 miles across the rugged Appalachian Plateau, through narrow valleys that are several hundred feet below the uplands, and joins the Allegheny River at Pittsburgh, Pennsylvania, to form the Ohio River. Valley elevations range from about 700 to 4,700 feet above mean sea level. Principal tributaries, in addition to the West Fork, are the Youghiogheny, Cheat, and the Tygart Rivers.

Climate:

The climate of the Study Area is temperate with a seasonal variation in temperature. The area is geographically in a region of frontal air-mass activity, being subjected alternately to polar and tropical air masses. Frequent and rapid changes in weather occur due to the passage of fronts associated with general low-pressure areas. The prevailing wind direction is from the west or has a westerly component.

The mean annual temperature is approximately 53°F. The average monthly temperatures are highest in July and lowest in January, ranging from 74°F to 34°F.

Precipitation is ample and well distributed through the seasons, with an average annual of 45 inches for the area above Clarksburg. The monthly average is a maximum in July and a minimum in October varying from 4.7 inches to 3.3 inches. The summer rains occur mostly from thunderstorms. They are usually confined to relatively small areas and are of short durations with high intensity rates. Precipitation in the fall, winter, and early spring months generally results from the passage of low-pressure systems over the basin. The average snowfall over the West Fork River Basin portion of the Study Area during the late fall-winter-early spring season is approximately 32 inches.

Principal Communities and Industries

The present population of the Study Area is approximately 2.84 million. The Pennsylvania portion of the Study Area is dominated by the Pittsburgh complex, while the portion in West Virginia is about equally divided between urban and rural populations.

Principal urban places and their populations(1960 census) are as follows:

Pittsburgh, Pa.	604,332	Morgantown, W. Va.	22,487
McKeesport, Pa.	45,489	Monessen, Pa.	18,424
Wilkinsburg, Pa.	30,066	Uniontown, Pa.	17,942
Clarksburg, W. Va.	28,112	Duquesne, Pa.	15,019
Fairmont, W. Va.	27,477		

Coal mining and steel production in the basin are of sufficient magnitude to be of national importance. Brewing, dairying, distilling, meat packing, tanning, and the manufacture of glass, by-product coke and chemicals are extensively practiced in the valley. Natural resources in addition to coal include limestone, gas, tillable land and abundant water power.

V. WATER RESOURCES OF THE STUDY AREA

Quantity of Water Available

The hydrologic aspects of the West Fork River at the Brownsville site have been previously described. The average discharge of the Monongahela River at Braddock, Pennsylvania, (about 11 miles upstream from the Allegheny confluence) is 12,440 cfs (22 years of record). At this location the maximum discharge was 201,000 cfs on June 5, 1941, and the minimum daily was 703 cfs in September 1946. Analysis shows the minimum daily flow at Braddock may be expected to be in excess of 1,820 cfs for 90 percent of the time and in excess of 1,350 cfs 98 percent of the time.

Two reservoirs are operated in the Monongahela River Basin to produce hydroelectric peaking power. These are Lake Lynn on the Cheat River and Deep Creek Reservoir on Deep Creek, a tributary to the Youghiogheny River in Maryland. In addition, two reservoirs are operated for flow regulation purposes. These are the Tygart Reservoir on the Tygart River and the Youghiogheny Reservoir on the Youghiogheny River (see Table 1). There are also 12 navigation locks and dams on the main stem of the Monongahela River.

TABLE 1

Reservoirs in the Monongahela River Basin

Name of Reservoir* / Name of Stream / State	Total Storage (acre-ft)	Usable Storage (acre-ft)	Flood Control Storage (acre-ft)	Low Flow Regulation Storage (acre-ft)	Dead Storage (acre-ft)	Storage Ratio (years)	Surface Area (acres)	Drainage Area (Sq.Mi.)	Date Completed	Use / Owner or Operator
Deep Creek										
Deep Creek / Maryland	106,060	92,975	--	--	13,085	1.2	4,500	68.5	1925	Power / Penn. Electric Co.
Youghiogheny River										
Youghiogheny R. / Pennsylvania	254,000	248,770	99,470	149,300	5,230	0.4	3,566	434	1943	Flood Control, Low Flow Regulation, Recreation / Corps of Engineers
Lake Lynn										
Cheat River / West Virginia	73,000	30,000	--	--	43,000	0.05	1,730	1,415	1926	Power / West Penn Power Co.
Tygart										
Tygart River / West Virginia	289,600	278,400	178,500	99,900	11,200	0.2	3,440	1,184	1938	Flood Control, Low Flow Regulation, Recreation / Corps of Engineers

* Only those reservoirs are listed that have a usable capacity of 5,000 acre-feet or more.

Fresh water supplies from ground water sources are available in some localities of the basin in quantities sufficient for small to moderate municipal and industrial usage. Quantities of ground water sufficient for farm and domestic use are generally available throughout the basin. Large supplies of good quality ground water are believed to be not available, although many parts of the basin have not been drilled nor tested for large ground water supplies. Yields of individual wells of moderate depth range from less than 1 to more than 50 gpm depending upon the hydrologic characteristics of the aquifer at each well location.

Quality of Water Available

Extensive water quality data have been collected over the years, but quality conditions are subject to considerable change due to changes in mining practices, mining control laws, previous programs of acid mine drainage control, and other factors.

The West Fork River is more highly mineralized than other streams in the upper reaches of the Monongahela River Basin (Table 2). Even in the upper basin near Weston, the specific conductance values indicate higher mineralization than any other stream examined (1). The water is moderately hard to very hard and of the calcium sulfate type. Moving downstream, the chemical quality deteriorates still further and the change is quite noticeable between Clarksburg and Enterprise. Concentrations of iron, manganese sulfate, and hardness increase and the pH values decrease resulting in acid water. Available dissolved oxygen concentration data indicate that the highest value measured

Table 2 *

WATER QUALITY

WEST FORK RIVER AT BROWNSVILLE, WEST VIRGINIA

Date	pH	Free CO_2 mg/l	Mineral Acidity mg/l	Total Acid mg/l	CO_3 mg/l	HCO_3 mg/l	Total Alkalinity mg/l	Hardness mg/l
8-23-54	6.8	10	0	10	0	30	30	51.3
8-22-55	6.8	20	0	20	0	45	45	34.2
8-27-56	6.6	15	0	15	0	30	30	34.2
8-26-57	6.6	15	0	15	0	30	30	34.2
8-25-58	6.4	10	0	10	0	15	15	17.1
8-24-59	6.5	10	0	10	0	20	20	17.1
8-22-60	6.0	10	0	10	0	10	10	17.1
8-28-61	6.3	10	0	10	0	10	10	17.1
6-10-63	6.1	9	0	9	0	24	24	17.1
6-24-63	6.1	8	0	8	0	23	23	17.1
7-8-63	6.1	9	0	9	0	21	21	17.1
7-22-63	6.0	11	0	11	0	13	13	17.1
8-12-63	6.3	9	0	9	0	11	11	17.1
8-26-63	6.2	6	0	6	0	7	7	17.1
9-9-63	6.3	13	0	13	0	27	27	34.2
9-23-63	7.0	27	0	27	0	13	13	17.1
10-14-63	6.7	11	0	11	0	27	27	17.1

* Data furnished by U. S. Army, Corps of Engineers.

exceeded 13 mg/l; the lowest was 4.7 mg/l; and the summer-time average was about 7.5 mg/l (85% saturation).

Raw water data from water treatment plants on the Monongahela River, from the Corps of Engineers, and from the Public Health Service and the West Virginia Department of Natural Resources' Water Quality Networks, were used as the basis for determining present water quality and the possible improvement by flow regulation from the Stonewall Jackson Reservoir. Available water quality data show only minor variation throughout the year.

In the Monongahela River at Charleroi, Pennsylvania, pH values were generally lower. Total acidity concentrations ranged from 30 mg/l at flows of about 2,000 cfs to 60 mg/l at flows around 500 cfs. Table 3 contains the average results from a 2-week water quality survey that was conducted in August of 1963 by the Public Health Service in the Monongahela River Basin. It can be concluded in a general way that throughout the survey period the surface water quality in the Monongahela and West Fork Rivers above Charleroi, Pennsylvania, was generally good except for the presence of acid. At Charleroi, Pennsylvania, (Station M-41.4), the average acidity concentration of 10 samples was 24 mg/l, the maximum was 39 mg/l, and the minimum was 14 mg/l. At this same station the hardness ranged from 108 to 284 mg/l, averaging 173 mg/l. This is much less than the average acidity concentration of 47 mg/l and hardness concentration of 402 mg/l that were found on the West Fork River near Enterprise (WF-20.0 at Gypsy).

Comparison of the latest survey data with that of 1940 shows that, in general, the acid content of the West Fork and Monongahela Rivers has not increased or decreased much in the past 23 years.

TABLE 3

Water Quality - Monongahela and West Fork Rivers *
1963 and 1940

River Mile	Flow (avg.) (cfs)	Temp. °C	D.O. (mg/l)	pH	Specific Conductance (micromhos per cm)	Hardness as $CaCO_3$ (mg/l)	Alkalinity as $CaCO_3$ (mg/l)	Hot Phenolphthalein Acidity as $CaCO_3$ (mg/l)	(tons/day)	1940 Data for Comparison ** Month	No. of Samples	Flow (cfs)	Hot Phenolphthalein Acidity as $CaCO_3$ (mg/l)	(tons/day)
WF-72***	41	21	7.2	6.1	155	64	6	0	0					
WF-31.9	200	22	8.1	6.8	420	209	27	3	2					
WF-20.0	315	22	7.3	4.1	910	402	0	47	40					
WF-4.4	280	23	7.7	4.1	633	265	0	29	22	June	3	936	46	116
M-128.7	West Fork River Confluence													
M-124.6	1,544	23	7.0	5.5	379	145	4	16	67	June	3	4,230	20	228
M-98.0	1,710	23	8.2	4.1	395	143	0	23	111					
M-90.7	1,940	24	8.2	3.9	391	133	-	24	126	Nov.	4	3,070	15	124
M-85.0	2,441	23	7.6	3.8	367	106	-	22	145					
M-41.4	2,402	24	8.9	4.0	487	173	-	24	156	Oct.	5	1,920	35	182

* Average of results from a 2-week survey in August of 1963 by the PHS as reported in the "Report on Pollution of the Interstate Waters of the Monongahela River System". (5).

** Data published in "Ohio River Pollution Control" (17).

*** Brownsville, W. Va. - unpublished data (average of 3 consecutive days, August 1963).

M - Monongahela River, miles above Pittsburgh, Pa.
WF - West Fork River, miles above Fairmont, W. Va.

V. THE ECONOMY

Introduction

An investigation of the population and economic characteristics and a projection of the probable growth of the area of concern of the reservoir project provides a basis for determining the water requirements of the area in terms of both quantity and quality.

The area of influence of the proposed Stonewall Jackson Reservoir includes the West Fork River Basin in West Virginia and also part of the Monongahela Basin in Pennsylvania. The West Fork Basin very closely coincides with the combined area of the five West Virginia counties of Monongalia, Marion, Harrison, Lewis, and Taylor. The area of concern in Pennsylvania is included in the counties of Fayette and Green and the Pittsburgh Standard Metropolitan area counties of Washington, Westmoreland, Allegheny, and Beaver. See Tables 4 and 5.

The growth of an area depends not only on the characteristics of the area itself but also in varying degrees on the type and extent of the growth of the Nation and the region of which it is a part. As a frame of reference for the West Virginia study area historical and projected employment for the State of West Virginia have been used. The projections for West Virginia were prepared by the National Planning Association of Washington, D. C. as part of their Regional Projection Series. For the Pennsylvania area of concern portions of the economic section of the Rowlesburg Reservoir project report,(2) which deals with the same area, are included here. The projections derived for the study area have been related to and found to be in agreement with the projections for the Monongahela subregion of the Projective Economic Study of the Ohio River Basin prepared by Arthur D. Little Company, Inc., Cambridge,

Table 4

Industrial Employment, West Fork River Study Area
(Harrison, Lewis, Marion, Monongalia, and Taylor Counties, West Va.)
1950 - 1960

Employment Category	1950 Number	1950 %	1960 Number	1960 %
Agriculture *	7,494	7.84	5,667	6.96
Mining	16,152	16.89	6,910	8.49
Manufacturing	19,957	20.87	16,038	19.71
Durable Goods	16,115	16.85	13,547	16.64
Furniture, Lumber, Wood Products	496	0.52	457	0.56
Primary Metals	1,181	1.24	1,003	1.23
Fabricated Metals **	3,288	3.44	3,746	4.60
Other Durables	11,150	11.65	8,341	10.25
Nondurable Goods	3,842	4.02	2,491	3.07
Food & Kindred Products	787	0.82	949	1.17
Apparel & other Fabricated Textile Products	553	0.58	657	0.81
Printing, Publishing, Allied Products	425	0.44	519	0.64
Chemicals and Allied Products	1,644	1.73	138	0.17
Other Nondurables and NEC	433	0.45	228	0.28
Total Extractive and Manufacturing	43,603	45.60	28,615	35.16
Service Industries***	46,031	48.15	46,215	56.79
Unemployment	5,976	6.25	6,551	8.05
Labor Force	95,610		81,381	
Population	257,000		232,000	
Labor Force, Percent of Population		37.2		35.1

* Includes a small number (less than one percent of total in category) in certain forestry and fisheries categories.

** Includes machinery, electrical equipment, and all transportation equipment.

*** These include essentially the non-commodity producing industries: Transportation, public administration, trade, construction, etc.

Table 5

Industrial Employment, Monongahela River Study Area

(Allegheny, Beaver, Washington, Westmoreland, Fayette, and Green Counties)

1940-1950-1960

Employment Category	1940 Number	%	1950 Number	%	1960 Number
Agriculture*	19,522	2.2	15,898	1.7	9,913
Mining	60,030	6.6	52,931	5.6	20,306
Manufacturing	251,608	27.7	317,669	33.8	320,807
Durable Goods	204,211	22.5	261,745	27.8	262,186
Furniture, Lumber, Wood Products	4,705	0.5	3,549	0.4	3,884
Primary Metals	181,289	20.0	150,391	16.0	138,600
Fabricated Metals**			75,602	8.1	90,567
Other Durables	18,217	2.0	32,203	3.4	29,135
Nondurable Goods	47,397	5.2	55,924	5.9	58,621
Food & Kindred Products	17,195	1.9	20,153	2.1	23,375
Textile Mill Products	1,020	0.1	1,348	0.1	578
Apparel & other Fabricated Textile Products	1,855	0.2	2,917	0.3	3,591
Printing, Publishing, Allied Products	7,635	0.8	9,803	1.0	13,280
Chemicals & Allied Products	4,332	0.5	7,881	0.8	9,732
Other Nondurables & NEC	15,360	1.6	13,822	1.5	8,065
Total Extractive and Manufacturing	331,160	36.5	386,498	41.1	351,026
Service Industries***	389,821	43.0	494,150	52.6	540,145
Unemployment	185,779	20.5	59,191	6.3	72,125
Labor Force	906,760		939,839		963,296
Population	2,328,226		2,448,529		2,614,199
Labor Force, Percent of Population		38.9		38.4	

*Includes a small number (less than one percent of total in category) in certain forestry and fisheries categories.

**Includes machinery, electrical equipment, and all transportation equipment.

***These include essentially the non-commodity producing industries: Transportation, public administration, trade, construction, etc.

Massachusetts.

Present Economy

The West Virginia Area

Extractive Industries

The production of minerals, including fuels, is very important to the economy of the West Virginia study area. Bituminous coal production is greatest in Marion, Monongalia, and Harrison Counties. Lewis County was one of the leading producing counties in the State in both gas and petroleum production. The number of employees in the mining industries declined from about 16,000 in 1950 to about 7,000 in 1960, a decline of 56 percent. During the same period, coal production decreased from 28.9 million tons to 23.0 million tons, a decrease from 20 percent of total State production to 19.3 percent. Between 1960 and 1961, coal production increased in four of the five counties and remained constant in the fifth.

For the most part, the coal mines in the area are well equipped. For example, in Monongalia, 5,982,000 tons of coal were produced in 1961; 99 percent of the coal production was from underground mines and 97 percent of that production was loaded by mobile loading machines and continuous miners. In Marion County, where 9,206,000 tons of coal were produced in 1961, 82 percent of the underground output was loaded by continuous miners as compared to 69 percent in 1960. Marion County moved from fifth place in the State in coal production to fourth place in 1961.

High voltage electrical transmission with the generating plants located at mine-mouth will most probably increase coal production in the area.

Stone is quarried in Harrison, Lewis, and Monongalia Counties. Glass

and engine sands are produced in Monongalia County, and some clay for building brick and heavy clay products is mined in Lewis County. Salt deposits underlie the area, but these same deposits extend under areas to the west where they are nearer to the surface and, therefore, more economical to reach.

In the study area, 35 percent of the total acreage is forested. Nearly all of the timber is hardwood. The annual growth of saw timber in the study area in 1960 was 22,676,000 board feet. It is not probable that there will be much of an increase in timber production in the study area.

Agriculture in the West Virginia study area has remained fairly constant in terms of the value of farm products sold over the past 15 years. However, the farm population, the number of farms, and the acres of land in farms have been steadily decreasing. In 1959 the acres of land in farms was only 61 percent of what it had been in 1945, and the farm population dropped from 15.9 percent of the total population in 1950 to 4.75 percent in 1960. The predominant type of farming in the West Virginia study area is livestock farming. There is very little vegetable and fruit production in the area and almost no high value field crops. For this reason, there is almost no land under irrigation in the area.

Manufacturing

Manufacturing employment in the five-county West Virginia study area represented 21.4 percent of the labor force in 1960, which was a decrease of 1 percent from 1950. Value added to manufacture in 1958 in this study area was approximately $127,082,000, as compared with $124,251,000 in 1954 measured in actual dollars. When deflated for price changes, the increase is cut to about 20 percent of that indicated by the constant dollar figures. Eighty-

six percent of the plants employ under 100 employees. This group includes all the plants in the manufacture of food and kindred products, lumber, and paper. Manufacturing in the study area is quite varied. In 1958, there were 234 manufacturing plants in the area. Included were all the manufacturing classes except tobacco, textiles, rubber, and leather. The leading manufacturing industry as measured by both number of plants and employment is glass manufacture. In terms of employment, this is followed by electrical machinery and primary metal.

Income

The per capita income in 1960 in the study area was about $1,750 as compared to $1,690 for the State.

The total personal income in the West Virginia study area in 1960 in current dollars was $405,799,000 and during the period 1940-1960, the income of the area had risen from $99,549,000 and remained about 13 percent of the State total income.

Transportation

The terrain of the study area is rugged, which tends to make transportation in the area difficult. However, river transportation, as part of the Ohio River system, extends to Fairmont; the Baltimore and Ohio Railroad runs through the basin from Weston into Pennsylvania, and also crosses the basin (east-west) at Fairmont and Clarksburg; two good highways run north-south through the basin and it is now planned to run an interstate highway route north and south through the basin. Commercial airlines serve the area, with an airport at Morgantown and another between Clarksburg and Fairmont.

Population

The population of the West Virginia portion of the study area increased slowly but at a fairly constant rate from 236,213 in 1930 to 237,100 in 1950, and then declined to 231,911 in 1960 (see Table 6). The rate of change in the five-county area has very nearly paralleled the rate of change in the State.

In 1960, about 46 percent of the area population was urban, 49 percent of the population was rural non-farm, and less than 5 percent lived on farms. Forty percent of the population lived in the cities of Morgantown, Westover, Star City, Grafton, Clarksburg, Fairmont, and Weston. The population of small towns amounted to 14 percent of the area population; thus, 54 percent of the area population in 1960 lived in "municipal areas."

The Pennsylvania Area

Monongahela River Study Area*

During the 50-year period from 1910 to 1960, the population of the aforementioned six-county area adjacent to the Monongahela River advanced steadily from 1.67 to 2.61 million. This rate of increase averages about half that of the Nation. The area is dominated by the Pittsburgh complex which has had a less than average rate of growth when compared to other Standard Metropolitan Statistical Areas in its size class for each of the last five decades.

Heavy manufacturing dominates the economy of the area. Major products include steel, aluminum, glass, and heavy mechanical and electrical equipment. This is a growing center for nuclear equipment, research, and development activities.

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*Taken from the report on the Rowlesburg Reservoir, Cheat River Basin, Public Health Service (2).

Table 6

Populations 1940, 1950, and 1960
MONONGAHELA AND WEST FORK RIVER BASINS

	1940	1950	1960
United States	131,669,275	151,325,798	179,323,175
Pennsylvania	9,900,180	10,498,012	11,319,366
Monongahela River Study Area	2,328,226	2,448,529	2,614,199
West Virginia	1,901,974	2,005,553	1,860,421
West Fork River Study Area	245,000	257,100	231,911
Morgantown Area (Morgan and Grant Districts as shown in the 1960 census)	34,214	42,583	40,407
Fairmont Area (Fairmont, Grant, Union, and Winfield Districts)	41,861	45,635	42,513
Clarksburg Area (Clark and Coal Districts, and Simpson)	51,012	54,773	51,532
Weston City	8,268	8,945	8,754

Total production has continued upward. The value of manufactured goods increased 25 percent in the past 10 years. Total personal income rose from $2.5 billion to $3.6 billion between 1949 and 1959, which is an increase of 45 percent as compared to the national increase of 75 percent. However, the per capita income exceeds the national average by about 20 percent.

Future Economy

Projected Economic Growth of Area The study area has been in a period of economic decline and high unemployment resulting from decrease in coal production, mechanization of mines and decrease in employment in primary metals in the Pittsburg Area. This period of decline should bottom out about 1970 with slow recovery thereafter.

The area's coal reserves, combined with good water transportation and the fact that the area is located in the midst of the manufacturing belt of the United States, are expected to be major factors in stimulating industrial growth (see Tables 7 & 8, Fig. II). The bulk of the future growth is expected to occur in the Monongahela Study Area where present developments attest to its attractiveness as a site for continued industrial expansion. This is a [illegible] ing center for nuclear equipment, research, and development activities.

The continued expansion of thermal-electric power production in the Monongahela River Basin seems probable. High voltage electrical transmission with the generating plants located at mine-mouth will most probably increase coal production. It is conservatively estimated that the national demand for thermal-electric power generation using coal will increase five-fold in the next fifty years. If the area's demand for electrical power approximates that of the Nation, there could be need for cooling water for an additional [illegible] million kilowatts between 1980 and 2010.

Less than half of the saw timber in West Virginia is now being harvested

Table 7
Industrial Employment, West Fork River Study Area

(Harrison, Lewis, Marion, Monongalia, and Taylor Counties - W. Va.)
1960 - 1985 - 2010

Employment Category	1960 Number	1960 %	1985 Number	1985 %	2010 Number	2010 %
Agriculture *	5,667	6.96	3,200	3.2	3,800	3.2
Mining	6,910	8.49	8,500	8.4	10,200	8.6
Manufacturing	16,038	19.71	19,200	19.0	23,000	19.4
Durable Goods	13,547	16.64	15,700	15.5	18,800	15.9
Furniture, Lumber, Wood Products	457	0.56	500	0.5	600	0.5
Primary Metals	1,003	1.23	1,300	1.3	1,500	1.3
Fabricated Metals **	3,746	4.60	5,200	5.1	6,300	5.3
Other Durables	8,341	10.25	8,600	8.5	10,400	8.8
Nondurable Goods	2,491	3.07	3,500	3.5	4,200	3.5
Food & Kindred Products	949	1.17	1,200	1.2	1,400	1.2
Apparel and Other Fabricated Textile Products	657	0.81	1,000	1.0	1,200	1.0
Printing, Publishing, Allied Products	519	0.64	800	0.8	900	0.8
Chemicals and Allied Products	138	0.17	200	0.2	300	0.3
Other Nondurables and NEC	228	0.28	400	0.4	500	0.4
Total Extractive and Manufacturing	28,615	35.16	31,000	30.7	37,100	31.3
Service Industries ***	46,215	56.79	64,000	63.3	76,800	64.8
Unemployment	6,551	8.05	6,100	6.0	4,800	4.1
Labor Force	81,381		101,100		118,600	
Population	232,000		280,000		336,000	
Labor Force, Percent of Population		35.1		36.1		35.3

* Includes a small number (less than one percent of total in category) in certain forestry and fishieries categories.

** Includes machinery, electrical equipment, and all transporation equipment.

*** These include essentially the non-commodity producing industries: Transportation, public administration, trade, construction, etc.

Table 8

Industrial Employment, Monongahela River Study Area
(Allegheny, Beaver, Washington, Westmoreland, Fayette, and Green Counties)
1960 - 1985 - 2010

Employment Category	1960 Number	1960 %	1985 Number	1985 %	2010 Number	2010 %
Agriculture *	9,913	1.0	5,700	0.5	5,000	0.4
Mining	20,306	2.1	11,300	1.0	15,000	1.1
Manufacturing	320,807	33.3	303,000	27.6	411,000	31.4
Durable Goods	262,186	27.2	247,600	22.4	310,000	23.7
Furniture, Lumber, Wood Products	3,884	0.4	4,300	0.4	8,000	0.6
Primary Metals	138,600	14.4	95,600	8.7	130,000	10.0
Fabricated Metals **	90,567	9.4	119,700	10.8	138,000	10.5
Other Durables	29,135	3.0	28,100	2.6	34,000	2.6
Nondurable Goods	58,621	6.1	55,400	5.0	101,000	7.7
Food & Kindred Products	23,375	2.4	22,100	2.0	35,000	2.7
Textile Mill Products	578	0.1	500	0.1	3,000	0.2
Apparel & Other Fabricated Textile Products	3,591	0.4	3,400	0.3	10,000	0.8
Printing, Publishing, Allied Products	13,280	1.4	12,500	1.1	20,000	1.5
Chemical and Allied Products	9,732	1.0	9,200	0.8	20,000	1.5
Other Nondurables & NEC	8,065	0.8	7,700	0.7	13,000	1.0
Total Extractive and Manufacturing	351,026	36.4	320,000	29.0	431,000	32.9
Service Industries ***	540,145	56.1	719,200	65.3	826,000	63.1
Unemployment	72,125	7.5	63,400	5.8	53,000	4.0
Labor Force	963,296		1,102,700		1,310,000	
Population	2,614,199		3,101,100		4,100,000	
Labor Force, Percent of Population		36.8		35.5		32.0

* Includes a small number (less than one percent of total in category) in certain forestry and fisheries categories.

** Includes machinery, electrical equipment, and all transportation equipment.

*** These include essentially the non-commodity producing industries: Transportation, public administration, trade, construction, etc.

POPULATION TRENDS AND PROJECTIONS

STONEWALL JACKSON RESERVOIR REPORT

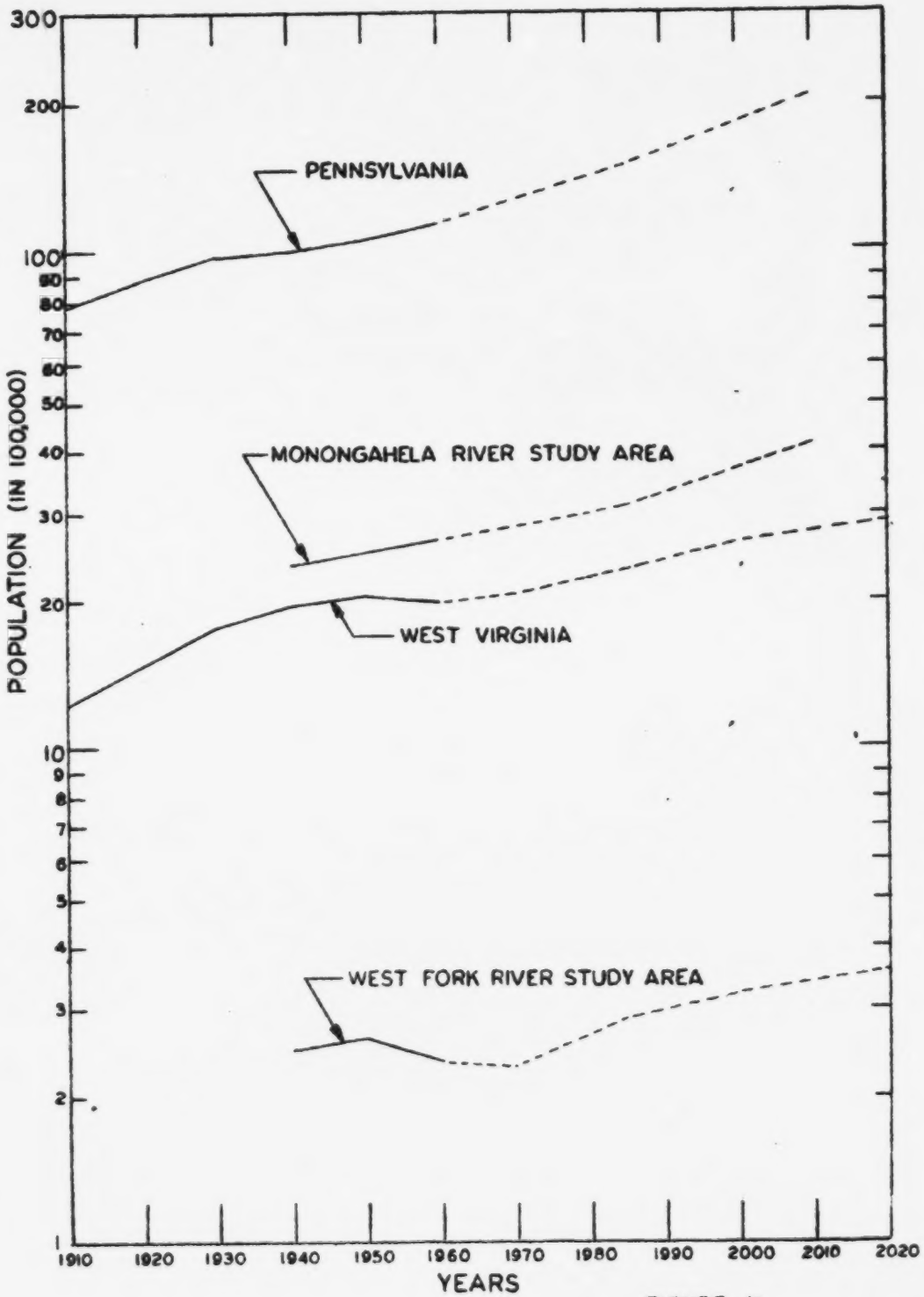

FIGURE 11

which hints that an increase in production might be expected. However, it is probable that this increase will not occur in the study area since other parts of the State have denser stands of timber making them more attractive to lumbering operations.

Current transportation facilities for heavy freight are good and will be improved by the proposed interstate highway route which is planned to be run north and south through the West Fork River Basin. This, in effect, will bring the area nearer to the markets of the heavily populated northeast.

Population Projections In making the following projections for the West Virginia study area, (see Table 9), the projections for the State prepared by the National Planning Association were used as the frame of reference. After considering past historical trends and opinions of economists and other people well acquainted with the area, it was assumed that the West Fork River study area will grow at least proportionally with the State. Historical shifts in employment were considered in projecting future employment.

Table 9

POPULATION

MONONGAHELA AND WEST FORK RIVER BASINS

1960, 1985 & 2010

	1960	1985	2010
United States	179,323,175	233,000,000	330,000,000
Pennsylvania	11,319,366	14,710,000	20,163,570
Monongahela River Study Area	2,614,199	3,101,095	4,100,000
West Virginia	1,860,421	2,291,000	2,742,500
West Fork River Study Area	231,911	280,000	336,000
Morgantown Area (Morgan and Grant Districts as shown in the 1960 census)	40,407	(high) 62,375 (low) 53,900	92,750 70,350
Fairmont Area (Fairmont, Grant, Union and Winfield Districts)	42,513	(high) 57,000 (low) 53,300	77,450 65,250
Clarksburg Area (Clark and Coal Districts and Simpson)	51,532	(high) 71,450 (low) 69,500	96,000 90,500
Weston City	8,754	(high) 13,200 (low) 12,375	18,700 16,900

Projections included here for the study area in Pennsylvania are from four sources: (1) population projections by counties for 1970 and 1980 from "The Population of Pennsylvania - Projections to 1980," prepared for the Pennsylvania State Planning Board by Temple University; (2) population and employment projections for 1985 for four counties in the Pittsburgh Metropolitan Area, derived from unpublished information prepared by the Pittsburgh Regional Planning Association; (3) population and employment projections for 2010 from the Public Health Service "Rowlesburg Reservoir, Cheat River Basin Report," and (4) independent employment projections for 1985, Fayette and Greene Counties combined. Each of the first three sets of projections are for different dates and to some extent different total areas. However, they are sufficiently consistent, and sufficient county data are included so that they will serve the purpose of this report.

VII. WATER REQUIREMENTS--MUNICIPAL AND INDUSTRIAL

Past and Present Water Use

Water uses within the study area include domestic water supply; industrial cooling, process, and other uses such as coal washing; water power and navigation; stock and wildlife watering; propagation of fish and other aquatic life; transport, dispersion, and assimilation of wastes; boating, and esthetic enjoyment. Water use for irrigation, swimming, bathing and other water-contact sports is limited.

Existing Sources of Water--Surface and Ground Water

Municipal The West Fork River has served as a water supply for many years. In 1889, the Clarksburg Municipal Water System began operation with a daily delivery capacity of 750,000 gallons. This was the first public-supply filtration plant established in West Virginia. Of the approximately 210,000 people now living in the drainage basin, nearly 50,000 obtain their water supply from the West Fork River and its tributaries. Table 10 lists the many municipal water systems in the river basin.

Further downstream, the Monongahela River is used extensively as a source for municipal supplies by communities along the river between Fairmont and Pittsburgh. Each day, almost 83 million gallons are withdrawn from the Monongahela River to serve the needs of nearly 600,000 persons. About 80 percent of this amount is withdrawn in the first 27 miles above the Allegheny River confluence. (see Table 11).

The city of Fairmont obtains its water from the Tygart Valley River and, in turn, supplies the needs of several nearby communities. Morgantown draws from the Monongahela River only during the Summer and Fall months

Table 10

Municipal Water Systems
West Fork River Basin

Communities	Population 1960	Source	Average Water Used mgd	gpcd
Lewis Co., W. Va.				
Jane Lew	426	WFR. Tributary	0.03	70
Weston	8,754	West Fork River	0.53	60
Weston State Hospital	3,000	West Fork River	0.59	200
Harrison Co., W. Va.				
Anmoore	1,050	Clarksburg	----	--
Bridgeport	4,199	WFR. Tributary	0.25	60
Clarksburg	28,112	WFR. & Tributaries	5.04	180
Lumberport	1,031	Tributary & Wells	0.08	80
Nutter Fort	2,440	Clarksburg	----	--
Salem	2,366	Tributary & Wells	0.15	60
Shinnston	2,724	Monongah	----	--
Spelter	500	West Fork River	0.25	500
Stonewood	2,202	Clarksburg	----	---
West Milford	367	West Fork River	0.03	80
Marion Co., W. Va.				
Fairmont	27,477	Tygart Valley R.	6.55	240
Monongah	1,321	Tygart Valley R.	0.85	640
Worthington	361	Monongah	----	---
	86,330		14.35	190

Table 11

Municipal Water Use
Monongahela River

Supply	Location River Mile*	Treatment**	Population Served 1961	Average Water Used GPCD	Average Water Used mgd
Pennsylvania					
South Pittsburgh Water Company	5	F,S,D	300,000	150	45.00
Braddock	11	F,D	12,500	160	2.00
North Versailles Township	13	F,D	3,000	233	0.70
Elizabeth	23	F,D	36,000	125	4.50
South Pittsburgh Water Company, Shire Oaks Sta.	27	F,S,D	100,000	160	16.00
Monongahela	33	F,D	11,500	130	1.50
Charleroi	42	F,D	60,000	100	6.00
Belle Vernon	44	F,D	6,500	62	0.40
Fayette City	46	F,D	7,000	72	0.50
California	52	F,D	3,000	67	0.20
Brownsville	56	F,D	12,000	83	1.00
Fredericktown	65	F,D	10,000	60	0.60
Isabella	71	F,D	1,200	83	0.10
Carmichaels	76	F,D	2,000	100	0.20
Southwestern Penn. Water Authority	77	F,D	10,000	180	1.80
Masontown	79	F,D	5,000	100	0.50
Martin	83	D	200	50	0.01
Dunkard Valley Joint Municipal Auth., Greensboro	85	F,D	1,600	44	0.07
Alicia	86	F,D	200	50	0.01
Robena Mine	87	F,D	2,500	36	0.09
West Virginia					
Morgantown	102	F,S,D	10,150	130	1.32***
Booth	109	D	500	130	est.0.06
National	114	None	100	130	0.01
Everettville	116	F,S,D	500	130	0.06
Jordan	118	P,S,D	200	130	0.03
	Total		597,150	139	82.66

*Miles to mouth of Monongahela River
**F-Coagulated, settled, filtered, possibly neutralization
S - Soda-ash, lime or zeolite softening.
D - Chlorination.
*** Total from all sources is 4.66 mgd.

when demand exceeds the capacity of the City's impoundments on Coburn Creek and Tibbs Run. Water supply for Point Marion is provided by the Cheat River.

Industrial The major industrial use of West Fork River streamflow is for cooling and occurs in the vicinities of Weston and Clarksburg. During periods of dry weather, however, sufficient streamflow does not exist for normal industrial cooling needs. The average total industrial water use, in addition to that furnished by the municipalities, is approximately 8.0 mgd. and 11.2 mgd for the Weston and Clarksburg areas, respectively. Commercial and light industrial processes use about 40 percent of the water produced by the Clarksburg water plant. Because of acid conditions, withdrawals from the West Fork River downstream from Clarksburg are limited.

Table 12 is a summary of industrial water use by river reaches on the Monongahela River. An examination of this table makes obvious the relative importance of the Monongahela River as a source of industrial water supply. In excess of 6,000 mgd is being withdrawn for industrial purposes on an average annual basis. Considerable industrial water is furnished through the public supply systems. However, by far the greatest amount of industrial supply is taken directly from the river at the point of use. Except for cooling water, a large part of the supply is neutralized and a substantial amount is softened.

As can be seen in Table 5, most of the employment in the Pittsburgh complex, which includes a substantial portion of the Monongahela River industrial area, is involved in the manufacture of primary metals. The steel mills in this area use large quantities of river water for cooling and process purposes.

Table 12

Major Industrial Water Use, 1961
Monongahela River

River Mile	River Water Pumped, mgd	Use, mgd				Treatment, mgd	
		Cooling	Process	Boiler	Other	Neutralization	Softening
0-5	3,676.6	2,827.0	242.0	83.3	524.3	175.3	5.3
5-10	280.0	218.0	58.0	3.7	0.3	280.0	3.7
10-15	444.6	336.0	99.8	8.3	0.5	331.5	8.3
15-20	45.0	35.0	9.0	0.8	0.2	45.0	0.8
20-25	206.0	185.0	13.0	6.3	1.7	205.0	6.3
25-30	250.1	250.0	-	0.1	-	0.1	0.1
30-35	0.6	-	0.5	-	0.1	0.5	-
35-40	21.6	20.0	1.2	0.4	-	10.1	0.4
40-45	179.9	179.9	0.7	0.2	-	0.2	0.2
45-50	74.3	58.0	5.0	0.3	11.0	65.3	0.3
50-70	715.0	240.0	475.0	-	-	475.0	-
70-90	171.8	-	87.2	-	84.6	1.0	-
90-110	9.4	7.0	1.4	-	1.0	-	-
110-128.7	4.7	3.1	1.2	-	0.4	-	-
TOTAL	6,079.6	4,358.1	994.0	103.4	624.1	1,589.0	25.4

In the West Fork River Basin the availability of ground water is variable. A number of small towns and villages are dependent on ground water for their water supply, but the use of ground water for major public supply systems is limited. However, in the past, ground water was an important source of supply for many public systems. In recent years the principal towns have been forced to develop surface water supplies due to dropping water levels, inadequate yield, and contamination of their ground water supplies. Some of these towns have retained their old wells for supplemental or emergency use.

Future Municipal and Industrial Water Requirements

Municipal As the population of communities along the West Fork and Monongahela Rivers continues to grow, as indicated by the economic analysis, and as the per capita demand for water increases there will be a substantial increase in water needs over the next fifty years. On the West Fork, the cities of Weston and Clarksburg will continue to show an increasing demand for water.

Along the Monongahela River below Fairmont for some 129 river miles to Pittsburgh, the projected needs for municipal water supplies are considerably greater. Presently, an estimated 83 mgd is withdrawn from the Monongahela River on an average annual basis. About 80 percent of this amount is withdrawn in the first 27 miles above the Allegheny River confluence.

Projected municipal water supply needs along the Monongahela and West Fork Rivers are shown in Table 13. Populations served are expected to increase 72 percent in the next 50 years and the per capita use of

Table 13

Projected Municipal Water Use
Monongahela and West Fork Rivers

Water Use Area	River Mile *	Estimated 2010 Population	Projected 2010 Water Use in gpcd	Projected 2010 Water needs in mgd
South Pittsburgh Area	0-30	695,320	172	119.4
Monongahela	30-40	17,700	153	2.7
Charleroi	40-50	113,200	160	18.3
Brownsville	50-60	23,100	156	3.6
Fredericktown	60-70	15,400	156	2.4
Southwestern Pennsylvania Water Authority.	70-80	28,000	161	4.5
Point Marion	80-90	10,200	128	1.3
Morgantown	90-129	85,700	170	14.6
Clarksburg	0-40	93,300	175	16.4
Weston **	40-70	22,350	175	3.9
TOTAL		1,096,070	171 (avg.)	187.1

* River miles measured upstream on the Monongahela and West Fork Rivers.

** Includes Weston State Hospital.

municipal water to increase from the present 139 gpcd to about 170 gpcd. On this basis, the municipal water needs will reach about 187 mgd on an average annual basis by the year 2010. Allowing for seasonal variations in draft, this figure will probably double on maximum days in the warm summer months to about 374 mgd (580 cfs).

By the year 2010, municipal water needs at Weston will be about 3.9 mgd; more than three times the present demand. Existing treatment and treated water storage facilities are limited and the present per capita demand in Weston is less than half that of other communities in the river basin. An immediate need exists for additional municipal supply. Likewise, municipal water needs for Clarksburg are expected to increase from the present 5.3 to about 16.4 mgd in the next 50 years. The time of first need for additional water supply is about 1980.

Owing to the distribution of use along the 129 miles of the Monongahela River to Pittsburgh, no single draft on the stream is likely to be in excess of the dependable flow, even after making general allowances for consumptive losses, etc.

The primary problem in the Monongahela River is one of quality control. As previously indicated, even though there are adequate quantities of water available at each point of use in the stream, the re-use of water is high and the result is a general degradation of water quality.

Industrial Present total industrial water use from the West Fork River averages, on an annual basis, about 19 mgd. By the year 2010, industries on the West Fork River will have an estimated total demand of 31 mgd for cooling, boiler, process, and other purposes.

Present industrial water use from the Monongahela River averages about 1721 mgd on an annual basis, exclusive of cooling water uses, and it is anticipated that it will increase to about 2830 mgd by 2010.

Table 12 shows that about 2,827 mgd of cooling water is withdrawn in the first five miles above Pittsburgh. Cooling water use is considerably in excess of the basic process, boiler, and general industrial requirements. The greatest single use is about 1,728 mgd for cooling, which occurs near the Ohio River confluence. Use of this amount of water at any one site would not be possible were it not for the canalized river system making possible a relatively high re-use of water even when streamflows are low. Water use for industrial cooling also poses a quality problem because cooling use increases the stream temperature reducing cooling efficiency for further cooling use, adversely affects aquatic life - if present, and causes a reduction in the organic waste assimilative capacity.

VIII. WATER QUALITY CONTROL

Municipal and Industrial Pollution

The largest waste sources in the West Fork River Basin are located : the Weston, Clarksburg, and Fairmont areas. Other population centers alc the river and its tributaries also contribute substantial waste loads as is apparent from Table 14. These communities comprised a total sewered population of more than 48,000 in 1963. Serious pollution problems now exist downstream from Clarksburg, Fairmont, and Morgantown, especially during extremely low flow periods.

A primary type sewage treatment plant is now under construction at Morgantown. Star City will convey sewage for treatment at Morgantown by means of an interceptor which is also now under construction. Clarksburg and Fairmont are actively planning for construction of primary treatment facilities, with Clarksburg construction expected in 1965.

The prominent industry in the river valley is coal mining and processing. Other types of industry are limited and contribute negligible waste loads to the West Fork River (Table 15). Acid from coal mines is a major stream pollutant throughout the Monongahela River Basin.

An acid stream is relatively void of aquatic live, thereby adversely affecting recreational and aesthetic values. Acid pollution causes corrosive damage to most structures located in or coming in contact with acid streams. An acid stream also requires more expensive treatment when its waters are used for municipal and industrial water supplies because the acid water requires greater amounts of neutralizing chemicals to produce acceptable finished water supplies.

Table 14

Principal Sources of Municipal Wastes
West Fork and Monongahela Basins

West Virginia - 1964

Community or Tributary	River Mile	Est. Sewered Population	Treatment Currently Required*	Treatment Given *
West Fork River				
Brownsville	72	50		None
Weston	66	8,300	S & Cl	P & Cl
Weston State Hosp.	66	3,000	S & Cl	S & Cl
Jackson Mill 4-H	57	500	P & Cl	Primary
Hackers Creek	50			
Jane Lew	(4)	500	P & Cl	None
West Milford	41	300	P & Cl	None
Lost Creek	40			
Lost Creek	(4)	600	- - -	None
Elk Creek	31			
Nutter Fort	(4)	2,300	S & Cl	None
Clarksburg	30	20,000	S & Cl	None
Spelter	23	500	S & Cl	None
Simpson Creek	23			
Bridgeport	(8)	2,750	P & Cl	None
Ten Mile Creek	19			
Salem	(13)	3,000	S & Cl	S & Cl
Lumberport	(1)	1,300	P & Cl	None
Shinnston	15	2,800	P & Cl	None
Worthington	10	350	P & Cl	None
Monongah	4.3	1,800	P & Cl	P & Cl
		48,050		
Tygart River	0 & 128.7			
Grafton	(18.6)	7,450	P & Cl	None
Monongahela River				
Fairmont	127	25,000	P & Cl	None
Rivesville	122	1,600	P & Cl	P & Cl
Morgantown	100	26,000	P & Cl	Under Construction
Westover	100	1,800	P & Cl	None
Star City	98	1,200	P & Cl	None
		55,600		

* Information provided by West Virginia Division of Water Resources.
P - Primary Treatment.
S - Secondary
Cl - Chlorination

Table 15

Principal Sources of Industrial Wastes
West Fork River Basin - 1963

Source	Type Industry	Type Treatment *
Clarksburg, W. Va.		
Carnation Company	Milk Canning	Aeration Tank and Biological Filter
McNichol Pottery Company	Pottery	No plans, questionable load.
Spelter, W. Va.		
Matthiessen & Hageler	Metal Refining	Settling Basins
Fairmont, W. Va.		
Reilley Tar & Chemical Corporation.	Chemical-Tar Recovery	Settling Basins under construction
Sharon Steel Company	Chemical-Coking	Lagoon

* Information provided by West Virginia Division of Water Resources.

Mine acid pollution poses a serious problem now but perhaps of even greater consequence is the potential pollution load that can be expected from this source in the West Fork River Basin unless appropriate abatement measures are employed. While the amount of acid mine drainage can not be tied solely to the tonnage mined, the following statistics (Table 16) show the extent of coal mining in the basin in 1962 and indicate that because of the large coal reserves, acid mine drainage can assume ever more serious proportions if not adequately controlled. It is known that many mines, abandoned for years, contribute significantly to the acid mine drainage problem.

Table 16

Active Coal Mines in the West Fork River Basin*

County	1962 Number of Mines Underground	1962 Number of Mines Surface	1962 Production, Tons Underground	1962 Production, Tons Surface	1961 Estimated Recoverable Coal Reserves, Tons
Lewis	3	7	11,713	152,380	1,378,742,000
Harrison	80	25	4,720,037	1,184,048	717,391,000
Marion	14	2	9,114,830	24,853	1,697,061,000
Totals	118	34	13,846,580	1,361,281	3,793,194,000

*Annual Reports of the W. Va. Department of Mines.

The Monongahela River is used extensively, not only as a source of water supply, but also to receive treated and untreated wastes from a large number of communities and industries. The population of the municiplaities discharging untreated sewage to the Monongahela River in Pennsylvania is approximately 153,000. Comparable waste loads contributed by industry can not be determined with a high degree of re ability.

Water Quality Objectives

The dissolved oxygen (D.O.) concentration in water is one index of water quality and its distribution within a river gives a measure of the balance between the oxygen supply and utilization within that system. Only by a study of the processes involved in this balance is it possible to assess the organic load which any stream network may receive without becoming seriously depleted of dissolved oxygen.

Objectives for dissolved oxygen were set in this study in relationship to the support of a desirable aquatic environment. The maintenance of a minimum of 5 mg/l of dissolved oxygen in the West Fork River and 4 mg/l in the Monongahela River at any point have been selected as objectives. These objectives can be met by providing storage for streamflow regulation which will maintain D. O. concentrations greater than the minim objective, except for one year out of ten, when the dissolved oxygen wi drop below the minimum at the point in receiving waters where the mum effect of pollution is felt. Streamflow regulation is considere necessary when the 7-day mean low flow, with a once-in-ten-year rec rrence frequency, is inadequate to maintain this quality objective. When minimum flows of less frequent occurrence prevail, flow regulation can substantially ameliorate water quality degradation.

Fish production is favored in near-neutral to slightly alkaline, moderately hard waters which are nearly saturated with oxygen; contain sufficient nutrients for good phytoplankton production; are free of injurious amounts of chemicals; have low turbidities; and are subject to not more than moderate fluctuations in water levels and flow velocities (15). Observation of minimum levels of dissolved oxygen in waters favorable to a good mixed fish fauna suggests that the dissolved oxygen should not be less than 5.0 mg/l at any time. However, fish can survive at D.O. levels somewhat below this value and in the absence of toxic substances or other adverse conditions, the above value is favorable for a mixed warm water fish population and its food organisms. The pH should be approximately 6.7 to 8.6 with an extreme range of 6.3 to 9.0; and the specific conductance at 25 degrees Centigrade should preferably be between 150 and 500 micromhos (14). An upper summertime temperature limit of from 75 to 85 degrees Fahrenheit is considered tolerable for warm water fisheries. Bottom discharges from reservoirs with summer water temperatures averaging from 10 to 20 degrees Fahrenheit below pre-impoundment temperatures have been known to virtually eliminate downstream warm-water fisheries (15). Provision of multi-level outlets in a dam makes it possible to control the quality of reservoir discharges, especially during periods of high temperatures and low natural flows.

The reduced objective of 4 mg/l for the Monongahela River reflects the large pollution loads entering the river in the Pittsburgh area. The Pennsylvania Sanitary Water Board, at this time, requires primary treatment of all domestic sewage and equivalent treatment of all other wastes discharged to the Monongahela River and it's tributaries upstream from the Allegheny County line (13). Intermediate treatment is required of all municipal and industrial wastes discharged downstream from the Allegheny County line which includes all of the Pittsburgh metropolitan area along the Monongahela and Youghiogheny Rivers. "Intermediate" treatment of sewage is such treatment as, in the opinion of the Sanitary Water Board, will remove practically all of the suspended solids; will remove at least 35 percent to 85 percent of the organic pollution load as measured by the biochemical oxygen demand test (the degree to be fixed by the Board in accordance with the conditions pertaining to each specific case); will provide effective disinfection to control disease-producting germs; will provide satisfactory disposal of sludge; and will produce a final effluent that is suitable for discharge into the receiving stream.

The resultant change in the chemical character of streams receiving acid drainage has been established and the detrimental effects assessed. Among the more serious damages is the reduction in alkalinity, lowering of the pH, increase in the total hardness, iron, manganese, aluminum, and sulfates. This tends to render the water more expensive to treat for municipal and industrial use. It also increases corrosion damages to structures in the stream. Normal biological processes in the stream are often impaired, causing the stream to become a less desirable habitat for biological life. One objective in improving an acid stream is to seek a balance in the acidity-alkalinity concentration. Under normal conditions, without adding acid contained in coal mine drainage, the Monongahela River

would probably have a pH of between 6.5 and 6.8. Therefore, any decrease in acidity concentrations in the streams involved in this study, at least to the limits of the foregoing objectives, would constitute an improvement in water quality.

There are many other desirable aspects associated with improving the quality of the streams under study. Storage requirements and the beneficial effects of its provision will be assessed in view of the foregoing water quality objective and other aspects related to water quality maintenance.

Flow Regulation

Quality control flow schedules in the West Fork and Monongahela Rivers are developed in this study based on maintaining flows to assimilate organic waste loads that are or will be discharged to these streams and yet not reduce the stream quality below the stated water quality objectives. In establishing minimum flow requirements for quality control it has been assumed that secondary waste treatment of municipal wastes and its equivalent for industrial wastes will be provided for all used water before it is discharged to the receiving stream. Even after application of adequate treatment, some pollutants reach the stream and cause adverse conditions in downstream waters. Regulation of stream flows can prevent or reduce damages from these residual materials.

Dissolved oxygen objectives were selected on the basis of present and anticipated fish and wildlife, and recreational uses. While the maintenance of an acceptable dissolved oxygen level is the most general indicator of the effects of organic wastes, it is not the only criteria of importance. Concentrations of dissolved solids and nutrients, which are little affected

by present waste treatment methods, are decreased by dilution flows thus reducing the potential for algal growth and associated taste and odor problems. Persistent organic materials in industrial wastes not now removable by treatment, are also reduced in concentration. Present waste treatment methods cannot economically remove all oxidizable organic materials, nor can they remove the nutrients or persistent or refractory materials, so that provision of flow regulation improves water quality in ways not possible by treatment alone.

Meeting river water quality objectives by flow regulation in addition to the provision of adequate waste water treatment will increase the potential of the stream to support aquatic life and protect its use for water-oriented recreational activities. Improved river water quality will also enhance the general aesthetics of the waterway, improve the health, social and economic environment of the resident population, contribute to the health and well-being of livestock and wildlife, prevent nuisance conditions, reduce concentrations of residual agricultural chemicals, protect and enhance land values along the stream.

The principal communities in the West Fork River valley discharging wastes to the stream below the proposed dam are Weston and Clarksburg, West Virginia. Quality control flows required in the West Fork River downstream from Clarksburg have been determined. The flows are based on waste loads expected from present and projected populations, plus allowances for industrial growth. Provision of adequate treatment of municipal wastes and equivalent treatment and/or control of industrial wastes has been assumed in establishing the wastes to be assimilated by

the West Fork River. In this report, adequate treatment has been considered capable of reducing the organic wastes by the equivalent of at least 85 percent at each source before discharge to a stream.

On the basis of the foregoing it was found that, by the year 2010, a minimum of 115 cfs would be required downstream from Clarksburg (River Mile 25) for quality control during the warm month of July. Lesser flows would be needed in the other cooler months of the year.

The 7-day mean annual low flow of the West Fork River at Enterprise (River Mile 13) with a once-in-10-year recurrence frequency is 17 cfs. This is the dependability used in this study in determining needs for quality control stream discharges for organic waste assimilation purposes. On this basis, a need exists for storage for water quality control in the West Fork River within the study period.

During the periods of drought, the City of Clarksburg often diverts the entire streamflow through its water treatment plant. Flow records are not available with which to accurately determine the low flow at this point, although it is estimated to be approximately 7 cfs. Several tributaries enter the West Fork River between Clarksburg and Enterprise.

Table 17 outlines the varying monthly flow requirements for desired stream quality control during the years 1960, 1985, and 2010. The draft on storage required to assure the needed flows has been estimated for the monthly mean discharges available at Clarksburg and is the annual total that must be available to supplement minimum streamflows that might be expected to occur in one year out of ten.

Table 17

Required Streamflow Regimen for Pollution Control Purposes
West Fork River Near Clarksburg, West Virginia*

	1960		1985		2010	
	Required Streamflow (cfs)	Annual Draft-on-Storage** (acre-ft.)	Required Streamflow (cfs)	Annual Draft-on-Storage** (acre ft.)	Required Streamflow (cfs)	Annual Draft-on-Storage** (acre ft.)
January	10	0	20	0	56	0
February	11	0	21	0	57	0
March	12	0	22	0	59	0
April	14	0	25	0	63	0
May	19	15	30	40	72	175
June	25	130	38	340	96	1595
July	30	170	45	450	115	2095
August	27	225	40	560	100	2730
September	21	205	32	540	80	2520
October	16	170	26	450	68	2090
November	12	55	22	140	60	640
December	10	30	20	80	55	355
Annual Average	17		28		73	
Total Annual		1,000		2,600		12,200

* Based on adequate treatment of organic wastes discharged to the stream and on adequate control of acid pollution.

** This is the additional quantity needed at ~~Pittsburgh~~ Clarksburg and does not include storage and transmission losses.

Flow requirements for waste assimilation purposes have been derived for the Monongahela River at Pittsburgh and are outlined in Table 18 (2). These flow requirements are also based on projected organic waste loads that will be discharged to the stream after adequate waste treatment.

High acidity concentrations in the West Fork and Monongahela Rivers have an inhibiting effect on the rate of decomposition of organic waste. The dissolved oxygen concentrations currently observed indicate a better quality of water than would actually exist under neutral or alkaline conditions. If acid mine drainage can be adequately controlled, minimum seasonal flows shown in Table 17 and 18 will be required to assimilate waste discharges expected in 1960, 1985, and 2010. These flows are based on anticipated growth in accordance with Table 13.

Reservoir discharges should be scheduled to meet the water quality objectives set forth in this report. This may be approximated by providing the minimum streamflow regimens presented in both Table 17 and 18. It should be noted that the flow schedules developed for the West Fork and Monongahela Rivers have been based on the assumption that discharges from Tygart River Reservoir will continue to maintain the equivalent of a minimum of 340 cfs in the Monongahela River below Fairmont. Maintenance of at least 500 cfs in the Monongahela River for cooling water use at the thermal-electric plant now being constructed near Point Marion will provide incidental benefits in terms of more efficient cooling and lower stream temperatures.

To predict the effects of West Fork River flow regulation on acid and hardness conditions, a study was made of the records of local water treatment plants and of recent stream surveys in the Monongahela River basin.

Table 18

Required Streamflow Regimen for Pollution Control Purposes in the Monongahela River at Pittsburgh*

	1960		1985		2010	
	Required Streamflow (cfs)	Annual Draft-on-Storage** (acre-ft.)	Required Streamflow (cfs)	Annual Draft-on-Storage** (acre-ft.)	Required Streamflow (cfs)	Annual Draft-on-Storage** (acre-ft.)
January February March	1,050	0	1,875	0	2,700	0
April May June	1,560	0	2.530	0	3,500	0
July August September	1,850	36,120	2,925	170,640	4,000	364,100
October November December	1,270	0	2,185	52,500	3,100	107,400
Average Annual	1,455		2,379		3,325	
Total Annual		36,120		223,140		471,500

* Based on adequate treatment of organic wastes discharged to the stream and on adequate control of acid pollution.

** This is the additional quantity needed at Pittsburgh and does not include storage and transmission losses.

Average acidity and hardness concentrations were determined at varying stream flows and these were then used to compute the reduction of acidity and hardness that may be expected for regulated discharges of 50, 100, and 150 cfs from the proposed Stonewall Jackson reservoir. Favorable improvements to the other previously mentioned aspects of stream water quality will also result from flow regulation by the proposed reservoir. Estimates of water quality benefits for these improvements are presented in Section IX.

Flows required to meet the present and future needs for adequate water quality in the Monongahela River are shown in Table 18. To meet these flow schedules, a total annual draft on storage to yield 36,120 acre-feet was needed to meet the 1960 requirements. By the year 1985, the needs will greatly exceed the storage capabilities of the proposed Stonewall Jackson multi-purpose impoundment.

Additional water quality control needs may be met by future reservoir developments in the Monongahela River Basin. The USPHS Ohio River Comprehensive Study presently under way will consider future water supply and quality control needs of the area in the context of basinwide needs. Storage in this project will be considered as a part of the Comprehensive Study.

Under present flow conditions the West Fork River is inadequate to meet water supply needs of Weston and Clarksburg. Storage in the proposed Stonewall Jackson Reservoir could meet future needs for water supply and stream quality control purposes to the year 2010.

No specific provision of storage for industrial purposes on the West Fork River is considered in this plan for future water requirements.

If at such time that new or existing local water-using industry would require additional storage for flow regulation, then such water may be supplied from the storage allocated to water pollution control for the Monongahela River; and this industry or group of industries would pay a proportional sum for the water used. It is probable that any water used for industrial purposes in the West Fork River basin will be of adequate quality by the time it reaches the Monongahela River and will again be available for water pollution control.

Owing to the fact that the Monongahela River is canalized throughout, it is considered that sufficient industrial water supplies are available for present projected future needs, except as use of the stream may be limited by quality degradation.

IX. BENEFITS

Water Supply - Municipal and Industrial

Evaluation Method Benefits may be derived from the proposed multi-purpose Stonewall Jackson Reservoir by allocation of storage to municipal and industrial water supply, waste assimilation, recreation, reduction of hardness and acidity concentrations and other quality improvements. Because of the impossibility of determining a value for each of these benefits separately, an alternative procedure has been adopted for placing a monetary value on flow regulation storage benefits. This procedure consists of determining the cost of providing the same benefits by the most economical, technically feasible alternative method available in the absence of the multi-purpose project. The cost of the most economical alternative is considered the minimum value of the project benefits in each case because it is assumed that the least costly alternative solution could be pursued in the absence of the multiple purpose project under study.

Alternative Procedure The projected needs for water supply and for flow regulation to maintain surface water quality were developed in preceding sections. Present and projected municipal water demands for the Weston and Clarksburg areas are summarized as follows:

Area	Demand, mgd 1960	2010
Weston	1.1	3.9
Clarksburg	5.3	16.4
Totals	6.4	20.3

Estimates of storage volumes required to satisfy the 2010 municipal water supply demand were developed to calculate the value of provision for municipal water supply in Stonewall Jackson Reservoir to these two communities. That municipal water supply needs exceed the minimum daily flow with a recurrence interval of once in thirty years is the basis for the recommendation that provision of water supply is needed.

In the West Fork River Basin, the most reasonable alternates to the propored multiple-purpose reservoir are other reservoirs which may serve one or more purposes. These alternate reservoirs would be constructed at the least costly locations capable of providing the same water supply volume or the same control of water quality as the proposed multiple-purpose impoundment.

The most economic alternative arrangement to provide for the projected municipal water needs of Clarksburg and Weston in the absence of the proposed multiple purpose project, is by development of a single-purpose reservoir located on Little Skin Creek, about three miles upstream from Brownsville. The possibility of drawing municipal water for Clarksburg from an alternative single-purpose impoundment about four miles from the city was also considered. However, consideration of storage, transmission, and treatment costs indicated that the single-purpose reservoir on Little Skin Creek would be the less costly arrangement.

Projected industrial water demands for the Weston and Clarksburg areas will exceed 30 mgd by the year 2010. Most of this water is needed for cooling purposes. There is an immediate need for provision of storage for industrial water supply as, often, insufficient streamflow exists

during dry-weather periods for proper once-through cooling.

One incidental benefit from flow regulations occurs at Fairmont. The municipal water supply intake is situated in the Tygart River a short distance upstream from the West Fork River confluence and near the upper end of the pool formed by Lock and Dam No. 15 on the Monongahela River. Occasionally, when Tygart River flows are low, poor quality waters from the West Fork River back up into the Tygart River and reach the municipal water intake at Fairmont. Regulated West Fork River flows would partially alleviate this situation by decreasing the concentration of acid and other pollutants in the navigation pool during low-flow periods.

Projected municipal water supply requirements of about 167 mgd and industrial requirements of about 2830 mgd, exclusive of cooling water uses, are estimates of total requirements and make no allowance for re-use along the 129-mile reach of Monongahela River above the Ohio River. This study indicates that no single water supply for either municipal or industrial purposes is expected to exceed the streamflow considered dependable for water supply purposes before the year 2010, the end of the 50 year study period.

The West Fork River Basin is in a mountainous area and many reservoir sites are available that could provide water for quality control. Water could be stored either in one large impoundment upstream from all waste sources, or it could be stored in various combinations of other available sites on the many West Fork River tributaries. To estimate the value of benefits for water pollution control in the West Fork River, a site near Brownsville has been chosen to provide the flows needed downstream

at the point of maximum pollution loading. This point of maximum load has been determined to below Clarksburg.

Water Supply Benefits The current cost of a single-purpose impoundment capable of providing an annual draft-on-storage of 1000 acre-feet for Weston and 5200 acre-feet for Clarksburg is estimated to be $2,486,000, including costs for the dam structure, land acquisition, and relocations. It is expected that the reservoir would be in operation by the year 1973. Water treatment and transmission costs for this alternative reservoir have not been considered as these costs would be the same for the multi-purpose project. Both reservoirs would occupy the same site for purposes of this analysis. The monetary benefits are based on converting annual costs on a 4 percent-20 year bonding schedule (considered reasonable for financing by the local communities) to an amortization period of 100 years with a Federal interest rate of 3-1/8 percent. Annual charges for interest and amortization amount to $88,000. Annual operation and maintenance charges for the 50-year period of project use (after 1973) are $8,000 for a total cost of $96,000.

Water supply storage could be sold to the using communities on a schedule of seven increments through the year 2003. Annual costs discounted to 1973 for each of these successive increments add to a total of $60,000. This is the present annual value of the benefit for the provision of a single-purpose reservoir, with payments beginning in the year 1973, which will be needed to serve the area's increased needs between 1973 and 2010.

Regarding water users along the main stem of the Monongahela River,

no need for storage for municipal and industrial water supply purposes was found and no monetary benefit for storage for municipal and industrial water supply purposes is expressed in this report.

Water Quality Control

Water quality control benefits are defined as the net contribution to public health, safety, economy, and effectiveness in use and enjoyment of water for all purposes which are subject to detriment or betterment by virtue of change in water quality.

The value of the benefits resulting from flow regulation for quality control is the sum of the benefits for each of the quality improvements accomplished. While waste assimilation is the primary benefit derived from flow regulation for water quality control, further additional incidental benefits of a widespread nature include hardness, acidity and corrosion reduction, increased minimum flows for cooling purposes, and decreased water temperatures. The benefit of each quality improvement is considered individually and described in monetary terms where possible.

Hardness Reduction Excessive hardness is undesirable in municipal and many industrial water supplies, such as laundries, carbonated beverages, metal finishing, dyeing and textile industries, food processing, pulp and paper, photography, and many others. Hard water causes excessive scale formation in water pipes, coils, tubes, and shells. Heat loss due to scale from one-fiftieth to one-ninth inch thick will be from 7 to 16 percent. In addition, costs for periodic draining of cooling systems, scale removal, and loss in production when these services are being administered must be considered.

Requirements for various municipal and industrial purposes differ considerably. Hardness over 100 mg/l becomes increasingly objectionable in municipal water supplies. Industries in the Pittsburgh area indicated maximum acceptable hardness concentrations ranging from zero to 200 mg/l(16). A hardness of 150 mg/l in raw water has been selected as a basis for approximating the value of benefits for hardness reduction resulting from dilution with softer water from Stonewall Jackson Reservoir.

Water quality data on the West Fork River at Brownsville for the period from 1954 to 1963 indicated that the hardness varied over a range from 17 mg/l to about 68 mg/l during periods of low flow. Analysis indicates that the hardness that can be expected in Stonewall Jackson Reservoir releases will be about 60 mg/l on an average annual basis.

The hardness of the Monongahela River at Charleroi at various levels of streamflow has been estimated from data for the years 1959 and 1960. The reduction in hardness resulting from several levels of regulation of the West Fork River by Stonewall Jackson Reservoir were estimated. West Fork River flows in the period of record analyzed were regulated at 50, 100, and 150 cfs, and the reduction in the hardness of Monongahela River flows was estimated at each level of sustained flow. For example, West Fork River flows of less than 100 cfs were increased to 100 cfs and the reduction in hardness in the Monongahela River at Charleroi resulting from the increased West Fork River flows was determined. It was found that maintenance of a minimum flow of 100 cfs resulted in an average hardness reduction of 5.3 mg/l for an average of 151 days per year. The average savings in treatment costs were then estimated for each level of assured West Fork River flow. This same procedure was followed to

determine hardness reduction in the lower reaches of the West Fork River.

Savings were estimated from the reduction of chemical and labor costs for treating the raw water of reduced hardness. Because the water treatment facilities are presently in existence and would still be needed at times, costs of plant construction were not included in the savings; only the savings in chemicals (lime-soda, averaging $20 per ton) plus the associated labor costs were considered.

Savings in treatment costs through hardness reduction in the West Fork and Monongahela Rivers for each of the three levels of regulated flow are shown in Tables 19 and 20. From these tables, if the minimum flow schedule for water quality control (Tables 17 and 18) were maintained, the approximate 2010 annual benefit for hardness reduction in the West Fork and Monongahela Rivers would be $33,000 and $6,000 respectively. Hardness reduction at Clarksburg decreases with increasing flows because concentrations are very high at natural low flows and fall off rapidly as flows increase to about 200 cfs.

While the value of these benefits are calculated separately, they are considered to be included in the monetary benefits evaluated in terms of the single-purpose project capable of meeting quality control needs of the West Fork and Monongahela Rivers.

Acidity Reduction As previously indicated, acid mine drainage is a severe problem in much of the Monongahela River Basin. While considerable effort has been directed to acidity control at the source, particularly for active mines, the degree to which this can be achieved cannot be determined at this time. Some of the adverse effects of high acidity can be alleviated by flow regulation by the proposed Stonewall Jackson

TABLE 19

Hardness Reduction - West Fork River

Regulated Discharge from Stonewall Jackson Reservoir, cfs		50	100	150
Average Number of Days per Year Hardness will be Reduced at Clarksburg		185	241	258
Average Hardness Reduction when Natural Flows are Less Than Regulated Discharge, mg/l		116	69	55
Average Annual Benefit, dollars				
Year	Volume of Water Treated, mgd			
1960	7	9,000	6,980	5,960
1985	17	21,800	16,950	14,450
2010	29	36,900	28,400	24,200

TABLE 20

Hardness Reduction - Monongahela River

Regulated Discharge from Stonewall Jackson Reservoir, cfs		50	100	150
Average Number of Days per Year Hardness will be Reduced at Charleroi		96	151	168
Average Hardness Reduction when Natural Flows are Less Than Regulated Discharge, mg/l		5.3	5.3	6.0
Average Annual Benefit, dollars				
Year	Volume of Water Treated, mgd			
1960	88	2,690	4,230	5,320
1985	115	3,520	5,530	6,950
2010	155	4,720	7,430	9,320

Reservoir. Although waters of the reservoir may become progressively more acid over the years, steps should be taken by the State to protect water quality of the reservoir. Since the West Fork River above Brownsville will contain less acidity per unit of flow during periods of high runoff than during the seasons of dry weather, storage and subsequent release of this less acid water during low flow periods will reduce the acidity concentration in the stream system below the reservoir. This will reduce the amount of chemicals needed at facilities where the acidity of the water must be neutralized before it can be used. The reduction in acidity concentrations that can be expected to result from flow regulation by Stonewall Jackson Reservoir has been estimated in the same manner that was previously presented for hardness reduction.

Available water quality data collected by the PHS and other government agencies indicates that the total acidity concentration of the West Fork River at Brownsville may be expected to range from 6 to 30 mg/l during all flows up to approximately 1300 cfs.

Analysis indicates that the average annual total acidity concentration in the post-impoundment period will be about 10 mg/l. Effective progress in future acid mine drainage abatement programs would tend toward even lower figures.

Acidity concentrations in the Monongahela River at Charleroi are much greater than in the West Fork River near Weston. During the period when the West Fork River is discharging less than 150 cfs at Weston, average acidity at Charleroi is 49 mg/l; when less than 100 cfs, 50 mg/l; and when less than 50 cfs, 53 mg/l. If West Fork River flows were

sustained at 150 cfs by the Stonewall Jackson Reservoir, the average acidity concentration in the Monongahela River would be decreased 2.7 mg/l over the period of 168 days when the reservoir would assure increased flow. An estimate of the savings in the cost of chemicals (lime) that will be realized by plants neutralizing water supplies withdrawn from the West Fork and Monongahela Rivers was developed for various regulated levels of West Fork River discharge. These acidity reductions and treatment cost savings are shown in Tables 21 and 22.

The volume of water neutralized for municipal and industrial purposes in the lower reaches of the West Fork River is negligible at this time. However, a range of values is presented to indicate the monetary benefits that could be attributed for this purpose. The values for the neutralization of the entire flow apply at Enterprise during the period when the natural flows at Brownsville are less than those shown (ie. 50, 100, or 150 cfs). Again, if the minimum flow schedule for water quality control (Tables 17 and 18) were maintained, the approximate 2010 annual benefit for acidity reduction in the Monongahela River would be $10,800.

While the value of these benefits are evaluated separately, these monetary benefits are considered to be included in the benefit evaluated in terms of the single-purpose reservoir to meet flow regulation needs on the West Fork and Monongahela Rivers.

Acid Corrosion Damages caused by the corrosive action of acid waters are of considerable concern not only to those municipalities and industries utilizing raw river water, but also to those firms engaged in river transportation and those charged with maintaining the extensive

TABLE 21

Acidity Reduction - West Fork River

Regulated Discharge from Stonewall Jackson Reservoir, cfs	50	100	150
Average Number of Days per Year Acidity will be Reduced at Enterprise	201	246	277
Average Acidity Reduction when Natural Flows are Less Than Regulated Discharge, mg/l	4	7	7
Average Annual Benefit, dollars			
Volume of Water Treated, mgd			
10	900	1,900	2,130
50	4,420	9,480	10,650
Entire streamflow	10,400	35,000	52,700

TABLE 22

Acidity Reduction - Monongahela River

Regulated Discharge from Stonewall Jackson Reservoir, cfs	50	100	150
Average Number of Days per Year Acidity will be Reduced at Charleroi	96	151	168
Average Acidity Reduction when Natural Flows are Less Than Regulated Discharge, mg/l	1.7	2.0	2.7

Average Annual Benefit, dollars

Year	Volume of Water Treated, mgd			
1960	250	4,500	8,300	12,500
1985	320	5,700	10,600	16,000
2010	435	7,800	14,400	21,700

public and private navigation facilities, docks, bridges, and other structures located on the Monongahela River. Most of the acidity in the upper Ohio River attributable to acid mine drainage originates in the Monongahela River Basin. The Public Health Service conducted a re-evaluation of acid corrosion damages to navigation interests in 1954 in connection with the previous report on the proposed Stonewall Jackson Reservoir. This re-examination was essentially an updating of results reported in the 1940 "Report of the United States Public Health Service on Ohio River Pollution Control" (House Document No. 266, 78th Congress). The estimates of acid corrosion damages occuring on the Monongahela River have again been updated by the Corps of Engineers and are as follows:

Boats	$354,000
Barges	483,000
Locks and Dams	40,000
	$877,000 (annually)

Benefits to structures and floating plant from the proposed reservoir operation result from reduced corrosiveness of the water and are based on the average per cent reduction in corrosiveness applied to the average annual damage from acid corrosion. Monetary estimates of the reduction in the above tangible acid corrosion damages which will be realized by flow regulation from the proposed reservoir are as follows:

Min. Continuous Discharge from Stonewall Jackson Reservoir (cfs)	Reduction in Damages (dollars)
50	3,000
100	6,000
150	9,000

In addition to the above reduction in damages to navigation facilities due to reductions in acidity concentrations, there will be reductions in damages to all other facilities that are adversely affected by contact with acid waters. It is not possible to estimate the full extent of these damages at this time.

Water Temperature Control Table 12 shows that in 1961, a total of 6,079 mgd of Monongahela River water was used for industrial purposes. More than 70 percent of the industrial water used along the Monongahela River was for cooling purposes, about 65 percent of which was concentrated in the first five miles of the Monongahela River above Pittsburgh.

National steel production in 1961 was about 98 million tons. Estimates of future production indicate this quantity will increase to about 175 million tons by 2010. Currently, 15 to 20 percent of the nation's steel production facilities are located along the Monongahela River. Even though the percentage of the nation's steel production facilities that will be located along the Monongahela River is expected to decrease in the future, a net increase in steel output is expected in the area.

In view of the above steel production figures and the fact that as much as 64,000 gallons of water may be required in the production of a ton of highly finished steel by methods currently employed in this area, the future need for relatively large quantities of cooling water in the Monongahela River is obvious.

Attendant to the production of steel and other allied products is the need for large quantities of electric power. Thermal electric generating stations use about 240,000 gallons of cooling water for each ton of coal consumed in power production. This power is vital to the economy of the area.

The result of these various cooling water uses is a general degradation of water quality caused by increased river water temperatures. In the 5 miles of stream above the Ohio River the water temperature varies between 2 and 10° F. above normal throughout the year. This increased water temperature results in greater streamflow requirements for quality control purposes when flow needs are based on dissolved oxygen and the assimilation of organic wastes (2).

Lower water temperatures are also beneficial to industry in that the efficiency of heat transfer in the cooling units is improved, thereby reducing the amount of water that need be pumped. The reduction in fuel consumption resulting from increased plant efficiencies can result in very substantial savings.

Flow regulation by the Stonewall Jackson Reservoir will result in a measurable reduction in the effect of waste heat on the temperature of the Monongahela River by maintaining greater flow volumes to assimilate and subsequently dissipate the heat.

For estimating purposes, the temperature of the increased regulated flow from the reservoir was assumed to be equal to the mean monthly air temperature. The temperature of natural or existing Monongahela discharges was assumed to be equal to the observed average water temperature for each month. The temperature reduction was determined as the difference between the existing Monongahela River water temperature and the weighted mean temperature of Monongahela and regulated West Fork River flows. Monetary benefits were based on the average number of days per year that these reductions might be expected and on a value of $0.05 per day per degree Fahrenheit temperature reduction per million gallons of cooling

water employed (2). The resulting value of the benefits to cooling water users are shown as follows:

Min. Continuous Discharge from Stonewall Jackson Reservoir (cfs)	Value of Average Annual Benefit (dollars)
50	4,000
100	7,000
150	11,000

A thermal-electric power plant with a capacity of 500 megawatts is now being constructed by the Monongahela Power Company on the Monongahela River a few miles upstream from the Cheat River confluence. To prevent excessively high stream temperatures, it is considered desirable that such an installation have enough water available so that recirculation of cooling water will not be necessary thus providing some assurance against possible thermal pollution. For estimating purposes, it is assumed that one cubic foot per second of cooling water is required per megawatt of power produced. Average daily flows were found to be less than 500 cfs for a total of 23 days during a recent year of near-average discharge in the vicinity of this new power plant. Flows averaged 462 cfs during this period. It has been found that once-through cooling raises the water temperature from 10 to 15 degrees Fahrenheit in passing through a thermal electric power plant and that for each 10 degree increase in temperature, 2 to 3 percent of this cooling water will be lost through evaporation. During the average period of 23 days each year when the stream waters will be reused, recirculation through the power plant will increase cooling water temperature almost 30 degrees Fahrenheit.

To determine the monetary benefit of increased streamflow to provide

500 cfs at the power plant, an approximate value of $5/day/cfs has been established(3). This figure multiplied by the total average daily flow increase during the period of need gives an estimated $4,370 annual incidental benefit for cooling water supply. This is believed to be a reasonable water quality benefit in that other uses are made of these waters for water quality control and the waters are not provided exclusively for the use of an industrial water user. The incidental benefit is part of the widespread, general benefit aspect of water pollution control.

Increased Organic Waste Assimilative Capacity It is not possible at this time to thoroughly evaluate the monetary benefits from all improvements in water quality. Economical waste treatment methods capable of complete removal of all waste materials are not presently known and many of the other aforementioned benefits are particularly difficult to completely assess in monetary terms. Other possible alternative methods of waste disposal or treatment that have been considered for this study include exportation of wastes to a point further downstream or out of the river basin, importation of water from an adjacent basin for dilution purposes, waste holding lagoons, periodically restocking streams, and other similar measures. However, none of these methods have been found to be feasible for this particular situation. For this reason, only provision of storage for flow regulation is presently considered capable of achieving the required quality improvements.

It is on this basis that the value of the over-all quality control benefit has been approximated in terms of the alternate cost of equivalent flow regulation by a single-purpose reservoir constructed at one of the sites in the West Fork River Basin currently being considered for potential development. The cost of a single-purpose reservoir at the least costly

location capable of providing the same control of water quality as the proposed multi-purpose impoundment represents the minimum value of the total water quality control benefits.

Provision of storage for flow regulation planned for the Stonewall Jackson Reservoir can improve the quality of the West Fork and Monongahela Rivers and the upper reaches of the Ohio River. The adverse effects of organic wastes remaining even after adequate treatment, as measured by the effect on dissolved oxygen, can be reduced to acceptable levels. Also, the concentrations of soluble nutrients resulting from domestic and other wastes, which are not significantly reduced by available treatment methods, can be reduced by dilution.

Although flow regulation needs in this study are based on the flow schedules developed for organic waste assimilation, provision of these flows will result in substantial improvement in other measures of stream quality. These other measures have been described on the preceeding pages and are important to the many legitimate uses of the rivers involved. The hardness of existing low flows can be reduced, resulting in savings in costs at municipal and industrial water treatment plants. The acidity of existing low flows can be reduced, resulting in savings in costs of neutralization at treatment plants and in costs of replacement of facilities whose lives are extended by the reduction of corrosion. The effect of thermal pollution can be reduced because of the greater volume of water available, thus reducing the temperature at subsequent points of cooling use and reducing the effect on organic waste assimilative capacity.

To meet the projected 2010 requirements for organic waste assimilation in the Monongahela River at Pittsburgh in 9 years out of 10 will require

a draft-on-storage of 471,500 acre-feet. This is much in excess of the capabilities of the proposed Stonewall Jackson Reservoir. Full development of the proposed reservoir would insure that the minimum requirements shown in Table 17 for waste assimilation in the West Fork River could be met. Provision of a single-purpose reservoir at Brownsville capable of yielding the following drafts-on-storage could provide water quality control benefits having the following estimated average annual values:

Annual Draft-on-Storage (acre-feet)	Average Annual Benefit (dollars)
20,000	350,000
40,000	700,000
60,000	1,050,000
80,000	1,400,000

These benefits are contingent upon provision of adequate treatment (85% BOD reduction) of all organic wastes being discharged to the West Fork and Monongahela Rivers and also on the assumption that means will be found in the future to sufficiently reduce or eliminate acid pollution in the river basin.

To provide the 2010 discharge schedule outlined in Table 17, this single-purpose project must provide an annual draft on storage of at least 12,200 acre-feet. While the benefits discussed apply primarily to the West Fork and Monongahela Rivers, widespread benefits to water quality will also be realized along the entire length of the Ohio River.

If the storage provided in Stonewall Jackson Reservoir is not sufficient to meet the quality control flow schedules, or if needs for other purposes prevent meeting quality control objectives at certain times, the value of the benefits must be appropriately reduced. The need

for storage for water quality control may be expected to continue to increase beyond 2010. These needs may be met by additional storage in Stonewall Jackson Reservoir or at other sites in the Monongahela River Basin.

It is recommended that multi-level outlets be included in the proposed Stonewall Jackson Reservoir Project. This would provide flexibility in reservoir operation to facilitate selecting those storage levels to supply the best downstream water quality possible and to assure that water quality objectives will be met by the project. A minimum requirement based on present knowledge of reservoir water quality would call for at least three outlets. Although variable-level outlets would be more desirable, provision of a low-level, median-level, and near-surface level (corresponding to average reservoir operation levels) should be sufficient. Keeping in mind pertinent measures of water quality, such as pH, temperature, and dissolved oxygen, installation of recording instruments to indicate water quality at the several levels would also be a very beneficial provision.

Benefits attributed to storage in the proposed Stonewall Jackson Reservoir are based upon a relatively uniform passage of streamflow to the Pittsburgh area.

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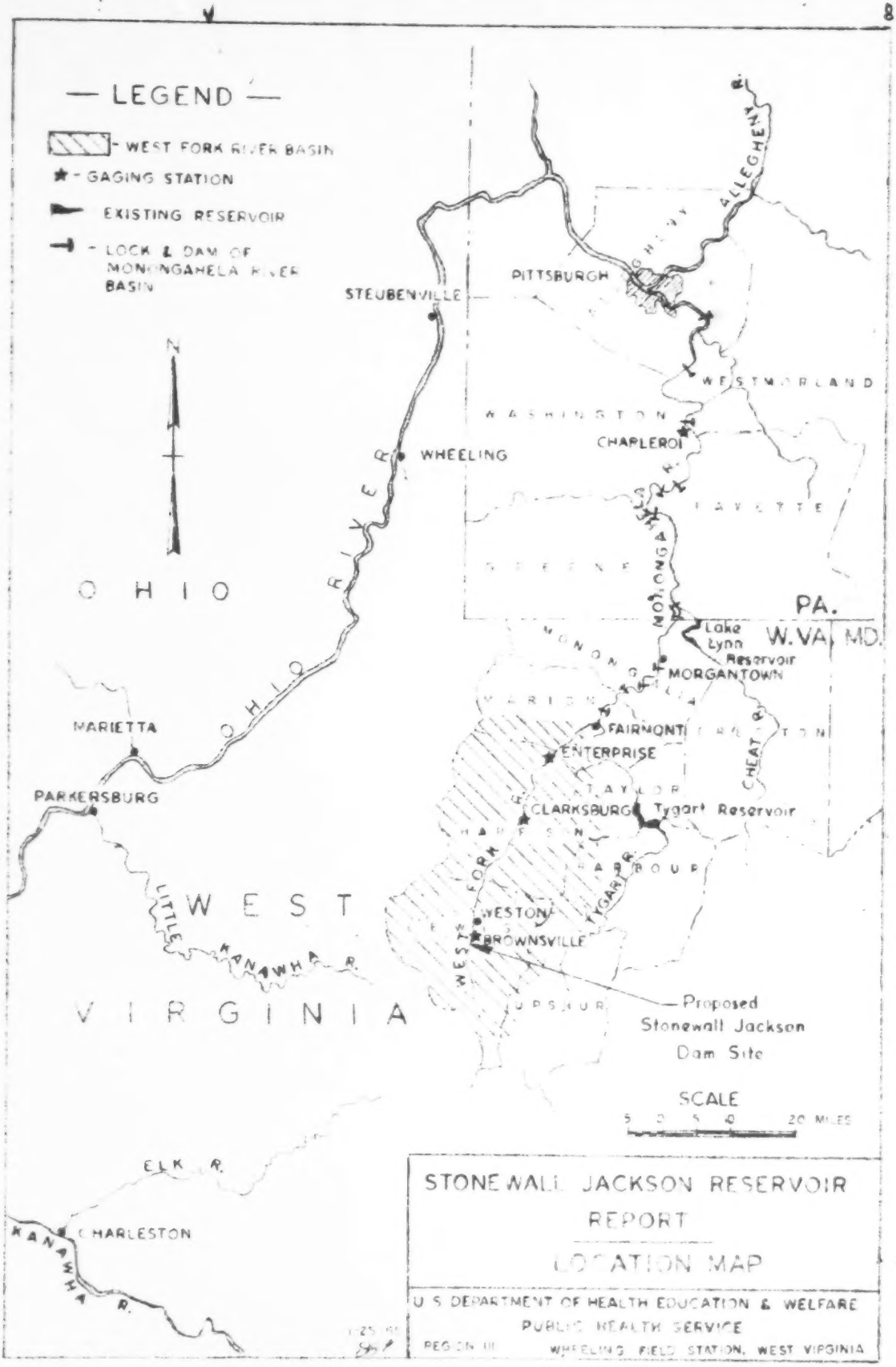

STONEWALL JACKSON RESERVOIR

REPORT

LOCATION MAP

U. S. DEPARTMENT OF HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION III WHEELING FIELD STATION, WEST VIRGINIA

FIGURE III